POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

APRIL
1935

Vol. XXXIX., No. 4

Published on the first of each month, copyright 1935 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

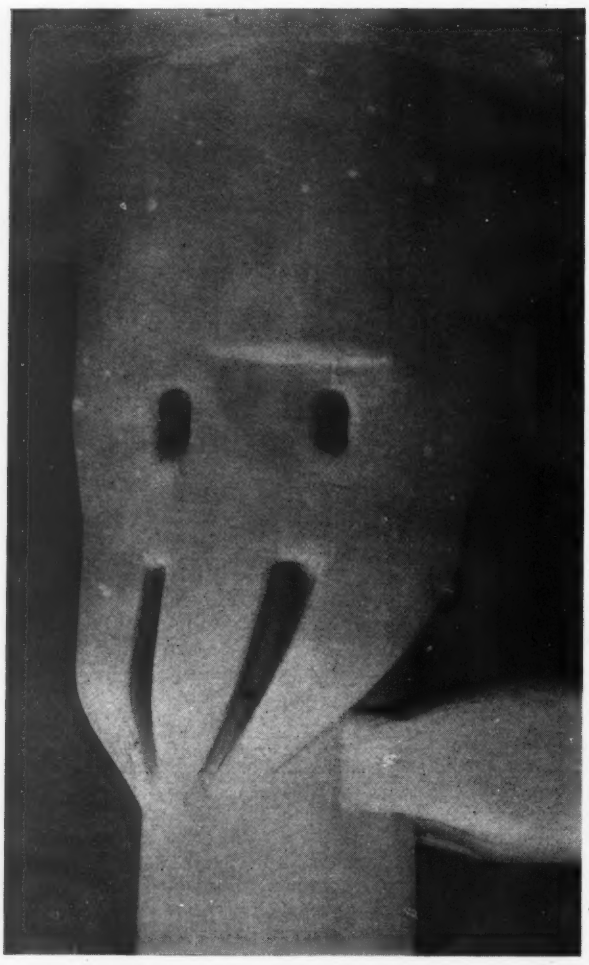
EDITORIAL STAFF: ARTHUR L. RICE, Editor. R. E. TURNER, Managing Editor.
A. W. KRAMER, RICHARD H. MORRIS, Associate Editors.

Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January 1 issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.
Circulation of this issue, 19,800

Startling Developments in

UNNATURAL HISTORY



OUR UNNATURAL HISTORY department was recently the scene of great commotion and controversy. It all started with the unusual specimen shown in the photograph above which a member of our Unnatural History staff claimed to have dug up in the vicinity of Beloit, Wisconsin. He was first observed dragging this specimen up the steps of our laboratory in the early hours of the morning and while his story was rather vague and incoherent, it seemed he found this thing on his way home from a party in Milwaukee. It was, of course, a find of great interest until the question of its classification arose and then it became a subject of violent dispute. The finder claimed it was the skull of a prehistoric Beloitotherm, a predatory beast of fearsome aspect which once roamed the campus of Beloit College scaring the co-eds half to death. Other members of the staff disagreed with this view, however. They insisted that it was not predatory but a scavenging beast—probably an extinct Dieselosauras Scavengerotis, which lived exclusively on a diet of CO_2 and which it obtained by inhaling the flue gas from the stacks of industrial plants around Milwaukee. A third faction further argued that both of these theories were baloney (their very words), pointing out that an animal with such a prominent proboscis and tusks could not have been an exhauster so to speak, but that it was unquestionably a species of rodent, of enormous proportions which required a carbonaceous diet of more substantial nature, such as Anthracite.

The adherents of the Scavengerotis theory immediately pooh-poohed this notion by pointing out that this could not have been the case because there is no Anthracite in Wisconsin—that the animal would have died of starvation. The "rodent" theorists replied that that merely proved their case—wasn't the beast dead? Then the "Scavengerotis" fellows said the "rodent" (they said rats) crowd was dead from the neck up.

We shudder to contemplate the possible consequence of this discussion had not an engineer from the Fairbanks Morse Co. appeared on the scene and knocked all these high powered theories for a row of exhaust casings. He explained that this strange looking thing was neither prehistoric, nor beast; that it was merely a core for a cylinder of their new scavenging type Diesel engines made at their Beloit factory and, furthermore, that they were looking at it upside down. This engine, which is known as the back flow engine, he said, improves scavenging and results in a 5 per cent decrease in fuel consumption. By this time, however, the unnatural history professors were so chagrined and disappointed that even a 95 per cent saving would not have impressed them.

Speaking of fuel savings, and Diesel engines, however, reminds us that on page 227 of this issue we present an article describing a rather interesting method of testing Diesel fuel. It is unusual because it involves the use of special test engines built solely for the purpose of testing the fuel. Our Diesel editor informs us that it is an excellent article, valuable to anyone interested in Diesel engines and we started to read it but when we came to such things as "knockmeters," "alphamethylnaphthalene" and octane and cetene numbers, we decided we needed a new vocabulary. Such articles may be fine for Diesel engineers but we found much more of interest in, say, the article on Connors Creek, or the one on page 232 telling about Dr. Alexanderson's new vacuum tube motor. And, of course, Zuce Kogan's "case studies" always are instructive and interesting. This time he describes how he cut the cost of electric power by merely using his head and power of observation in reading meters.

WITH THE EDITORS

Diesel Supremacy

DUE TO PECULIAR ADVANTAGES, the Diesel engine is firmly entrenched in the power field with good prospects of a substantial foothold in certain quarters of the railroad and automotive industry. These advantages are many, yet there is no question but that high thermal efficiency was the major force motivating the persistent development in the face of early discouragements.

Not only is the Diesel the most efficient of all thermal prime movers, but the efficiency curve over a considerable range of the load curve is flat and, extremely important, the efficiency bears little relation to size. This means that the small plant has the same advantage of low fuel cost as the large plant and units can be added in convenient sizes as needed to take care of load increases.

The most spectacular gains of the Diesel have been in the municipal plant field, especially in remote, isolated or outlying districts with loads not large enough to justify power transmission lines from a utility system. The plant site presents few problems as the fuel is not dirty or bulky and there is no smoke, dust or ash problem. The industrial field has also been fertile soil for the growth of the Diesel in districts where power costs are high or the utility service not up to the desired standard of reliability.

Growth of the Diesel in the utility field has been slower, due perhaps to the small sized units available. Of recent years this limit has been raised considerably and units of 10,000 kw. are now available with units of around 5,000 kw. sufficiently numerous to give adequate performance data. Of course, even 10,000 kw. comes far from 160,000 kw. now common in steam turbine plants, although it is doubtful if sixteen 10,000 kw. Diesel units would offer a much more complicated operating problem than, say, one 160,000 kw. turbine, two boilers and the necessary auxiliaries.

The future of the Diesel is bright, especially in the industrial field where waste heat recovery and coordination with steam equipment offers unusual opportunities of further increasing the already high thermal efficiency. In a recent address before a group of Engineering Societies in Chicago, Frank S. Clark, consulting engineer, of Stone & Webster Eng. Corp., said, "This type of prime mover is now capable of as reliable operation as others that are thermally actuated and consequently is adaptable to the same class of service . . . (and) . . . provides a simple, self contained, easily operated plant, whose first cost and running expenses are comparable with those of a steam plant of like capacity." This well deserved but belated compliment is significant coming as it does from one thoroughly familiar with the public utility industry, which, publicly at least, has always considered the Diesel a painful thorn in its side.

Plant Operating Policy

ONE OF THE problems that confronts the management of a power plant is to decide on policies of upkeep, repair and replacements prior to carrying out a program of general rehabilitation and modernization. As a rule, such operating policies are generally conceded, by the owner of the plant, as within the authority of a competent engineer as the expense is comparatively small and the need may demand immediate action on the part of the engineer in charge. To rehabilitate or modernize a power plant requires more capital and in many cases involves a study of conditions outside the power plant walls with which the engineer may not be conversant, so the management usually reserves authority in such programs.

While it may not be within the engineer's province to dictate the complete policy affecting the operation of the plant, much confusion can be averted if the engineer in charge is informed on the plans contemplated by the owner which involve the power plant in any way. If major changes or additions are to be made within a reasonably short time, the engineer would be justified in cutting down his expenses for repairs and replacements by making them more temporary in character than he would if he thought no changes were contemplated. Many a plant, however, has worn out before its time due to resort to temporary expedients where permanent repairs or replacements should have been made. For the sake of economy, the engineer should insist upon the formulation of a plant operating policy.

The Designer's Paradise

WHEN THE engineer starts to design a piece of equipment, one of the first things to be considered is the kind of material to be used in its construction. The physical characteristics usually take first place in consideration of metals used in the design of equipment. Frequently, however, the chemical characteristics such as the resistance to corrosion or acids, the effects of high temperature, the machinability, the ability to dampen vibrations or some other one or more of a dozen different characteristics plays a major part in the selection of the most suitable material.

Only a few years ago, the pure metals were depended upon almost entirely, probably because they were best understood. Today, however, with advances in the science of metallurgy, the designer has a much wider range of materials from which to choose. In fact, he is no longer compelled to choose, but actually designs his metals to give the predominating characteristics which he desires by incorporating the proper percentages of iron, carbon, nickel, chromium, vanadium, copper, tin, lead, zinc or what not into an alloy having special characteristics. What a paradise compared to the lot of a designer 20 yr. ago!

Revamping *of* Connors Creek *t*
32 Per cent Saving in

WHEN CONNORS CREEK STATION of The Detroit Edison Co. was built some twenty years ago, it represented the "last word" in power plant engineering technique. Its turbo-generators were the most efficient that twenty years of turbo-generator practice had been able to evolve and its 225 lb. pressure boilers represented high pressure practice at that time. Its auxiliaries also were selected with the object of securing a high degree of economy in the heat balance of the station, consistent of course with the standard of reliability the company always demanded. With its total generating capacity of 180,000 kw. and its heat rate of 19,000 B.t.u. per kw-hr., it was one of the foremost generating stations in this country.

Its subsequent performance fully demonstrated the high quality of its design. For many years this station, together with Delray, and later the Marysville Plant 55 miles north of Detroit, divided the load of the city of Detroit between them, but Connors Creek carried the larger share because of its superior capacity and economy. Although rated at 180,000 kw., at various times it carried as high as 183,000 kw. with no difficulty. It was singularly free from "shut downs." The use of distilled make-up water kept the boilers entirely free from scale, and during the period of the first 9 yr. continuous operation (1915-1924) only twenty tubes were replaced in the entire plant for all causes. When it is considered that there were 14 boilers with 1564 tubes each, a total of 21,896, this is rather an enviable record. There were no tube failures in service.

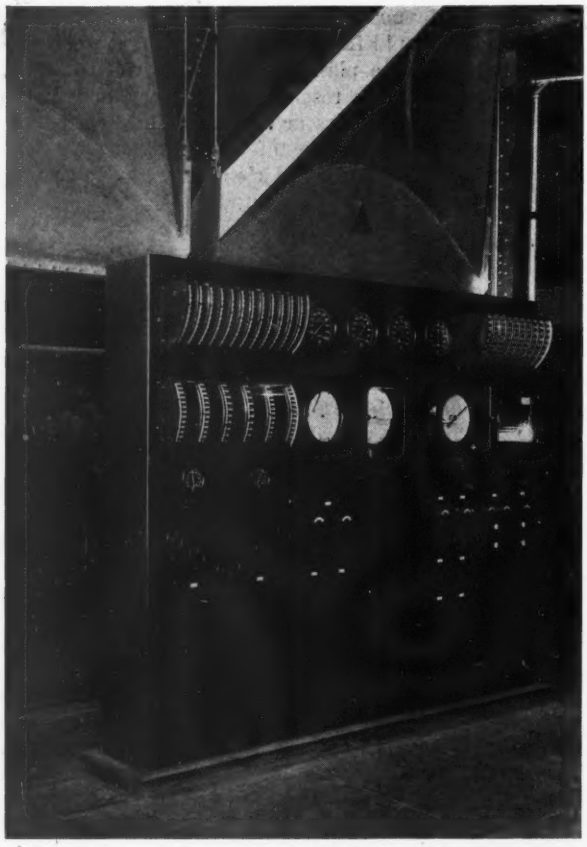


Fig. 1. Each new boiler is controlled from one of these elaborate control panels

Twenty years after Connors Creek Station was built, therefore, found it in as good an operating condition as the day it was started. It had received the most careful maintenance and the equipment was in perfect condition, good, easily, for another twenty years of service.

But in these twenty years between 1914 and 1934 the art of engineering had advanced. Though the method of generating electric power from fuel had not changed fundamentally, there had been great development in the details of the steam-electric generating cycle. During that time boiler pressures had increased from 200 or 300 to 600, 1200, 1800 and even 3400 lb. Steam temperatures likewise had mounted from 400 or 500 to 600, 800 and even, in the case of the experimental Delray turbine, to 1000 deg. F. There had been great development in the concentrations of high capacities, and boilers with capacities of 1,200,000 lb. of steam per hour had been produced. This had been accomplished by radical changes in furnace structure and design, by the preheating of air for combustion to high temperatures and by improvements in methods of control.

In the use of steam, that is, in the design of steam turbine equipment, corresponding advances had been made in those twenty years. An entirely new method of feedwater heating had been evolved, a method involving the extraction of steam from intermediate stages of the turbine and sending that to heaters—the regenerative cycle as it is called. Turbines had been built for continually increasing steam pressures and temperatures in accordance with the rise of boiler pressures. New methods of construction, improved blading design, refined methods of balancing, had made large and more efficient turbines possible. The technique of making high capacity reduction gears had made turbine driven direct current house generators possible.

All these advances had greatly increased the thermal efficiency of steam stations. From good practice of around 17 per cent in 1914, thermal efficiencies

to Effect Fuel

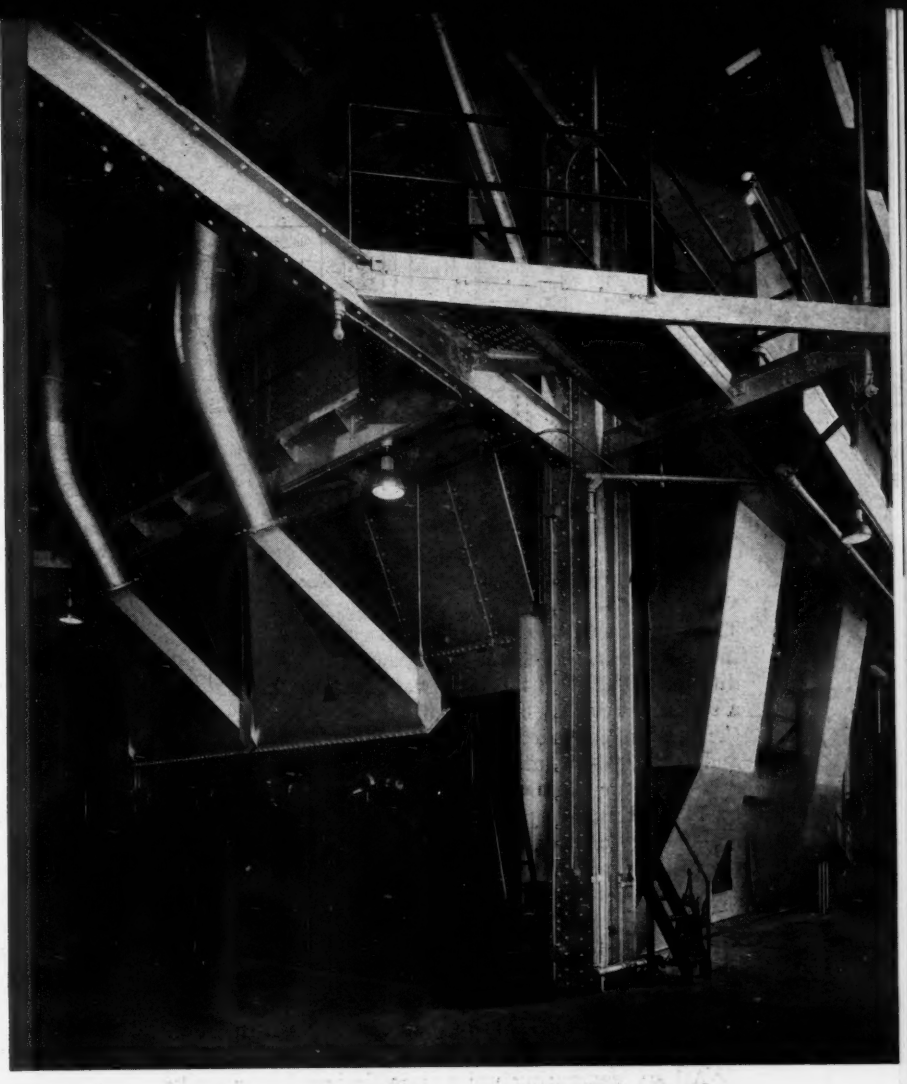


Fig. 2. One of the new 330,000 lb. per hr., 600 lb. pressure, double ended boilers at Connors Creek Station

had increased to around 30 per cent in 1934. Whereas the heat rate of Connors Creek Station was around 19,000 B.t.u. per kw-hr., in 1934 stations of 12,000 and 13,000 B.t.u. were common.

It was because of these remarkable advances in steam station design as related to efficiency that the engineers of The Detroit Edison Co., several years ago, began to consider the possibility of improving its performance. True, the station was in perfect operating condition, but preliminary calculations indicated that the possible increase in thermal efficiency by the use of modern equipment would warrant the expenditure of a considerable amount of capital in making the necessary changes. Detailed analysis and a careful study of all the factors involved indicated that by raising the existing steam pressure from 225 lb. per sq. in. and 600 deg. F. to 600 lb. and 825 deg. F. by means of new, double ended bent tube boilers with air preheaters and economizers, and by the use of extraction feedwater heating, the station heat rate would be decreased from 19,000 B.t.u. to less than 13,000 B.t.u.—a decrease of 32 per cent.

Naturally this attractive gain in economy was highly desirable, so a plan of rehabilitation was decided upon and work on the initial step started about a year ago. This initial step, or rather the first stage of the initial step has now been completed, but the reconstruction program will extend over a period of several years. The initial step in the program involves the installation of four new high pressure boilers and three 30,000-kw. generating units, to replace three 20,000-kw. units. The first two boilers and the first of the 30,000-kw. generating units are now in operation. The remaining two boilers and turbines are in course of erection and will be ready for service in the fall of this year.

This plan of rebuilding Connors Creek Station was not as simple a problem as that ordinarily presented by the design and construction of an entirely new 13,000-B.t.u. station. In the light of modern design it is a comparatively simple matter to design a new plant of that order of thermal efficiency. But to take a station 20 yr. old with a heat rate of 19,000 B.t.u. per kw-hr. and with a minimum of cost and constructional changes, convert that station into a modern plant delivering energy at less than 13,000 B.t.u., per kw-hr. involves problems which the designer of a new station never encounters. To begin with, as much of the existing equipment as possible must be retained. This involves not only a study of the possibilities of existing equipment under modified conditions but also of the possibility of modifying the equipment itself to fit into the new pictures. Then, of course, there is the question of clearances, of utilizing existing foundation structures and finally the matter of keeping the existing plant in operation while the changes are in progress.

Station Built in 1914

To describe the rehabilitation program in detail it is necessary to understand the conditions existing in the old station. As stated, Connors Creek dates back to 1913-1914 when construction work on the initial installation was first started. The first installation consisted of three 20,000-kw. turbo-generators but a few years later two 45,000-kw. units were added.

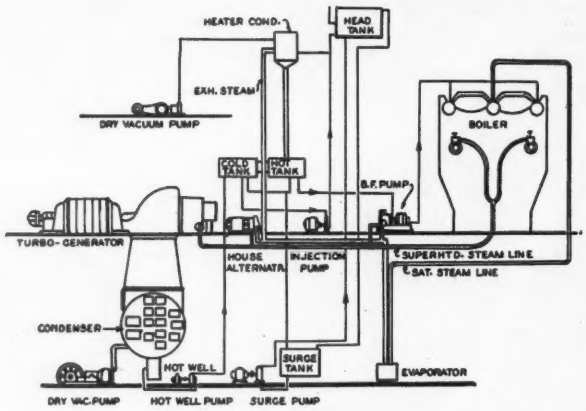


Fig. 3. Flow diagram of old turbines

These machines occupied the entire turbine room. To increase the reserve turbine capacity, however, an additional 30,000-kw. machine was installed in 1920, in a separate room at one end of the boiler house. Thus the station consisted of 3—20,000-kw., 2—45,000-kw. and 1—30,000-kw. units, a total of 180,000 kw.

Steam for these six generating units was supplied by 14 Stirling, W type boilers, each with 23,653 sq. ft. of effective heating surface and operating at 225 lb. per sq. in. pressure. These units were stoker fired with double 13 retort, two ram Taylor stokers, driven by direct current motors. The stokers were served by forced draft fans driven by 120-hp. direct current motors. No induced draft fans were necessary, the station having seven self-supporting steel stacks rising to a height of 240 ft. above the anchorage on the roof, 351 ft. above the ground level.

All six generating units were designed to operate at a throttle pressure of 225 lb. gage and exhausted into single or two-pass surface condensers. In addition to the main generating units there was also installed six house turbo-generators and six synchronous motor-generator sets supplying direct current for the auxiliaries. All auxiliaries with the exception of three turbine-driven standby boiler feed pumps and one general service pump, were driven by direct current motors. The six house turbines operated in synchronism with the main generators so that power for the motor generator sets could be taken either from the main system or the house turbine depending upon the amount of exhaust steam required for feedwater heating.

The feedwater cycle was rather interesting. The house turbines exhausted into five barometric condensers called heater-condensers and located just under the boiler room ceiling. The cooling water for these condensers was the condensate from the main surface condensers. Thus these condensers on the auxiliary turbines served as feedwater heaters on the main system. The arrangement is shown in Fig. 3 which is a flow diagram of the old station system. Hot water discharged through the barometric legs into hot water feed tanks was delivered directly to the boiler feed pumps. Make-up boiler feedwater was distilled from river water in double-effect evaporators.

So much for the existing plant. The arrangement of the revamped station is shown in Fig. 5, that is, as regards to the initial rebuilding program. Four of the 14 boilers, it will be noted, have been replaced with new large, high pressure units. Two of these, Nos. 1 and 2, are already in operation; units 3 and 4 are in course of erection. The three new 30,000-kw. generating units (replacing the 20,000-kw. machines) are shown in place. The first of these, unit No. 8, is in operation while the other two, units 9 and 10, are in course of erection and will be ready for operation in the fall of this year.

The two 45,000-kw. units, Nos. 4 and 6, are to be replaced with two 60,000-kw. machines at a later stage in the program. Finally, an addition to the turbine room has been built in which will be placed two additional 60,000-kw. units. Thus the ultimate station will have 3—30,000-kw. machines and 4—60,000-kw. machines, a total of 330,000 kw. as compared with 180,000 kw. in the old station.

While the three 30,000-kw. units have been referred to as new units, they are only partly new. Because of stage bleeding and increased initial pressure, it was found that the condensers of the old 20,000-kw. units would serve turbines of 50 per cent greater capacity. Thus, the condensers of the old 20,000-kw. machines are now serving the new 30,000-kw. machines. It was found possible to use the old foundation, exhaust casing, pedestal bearings, oil base and parts of the atmospheric relief valves. Of course the same condenser auxiliaries also are used insofar as possible.

The electric generator for the first of the 30,000-kw. turbines was taken from the old 30,000-kw. unit installed in the separate room at the end of the boiler house. The generator for unit No. 9 is being taken from an old 30,000-kw. machine formerly installed at Delray Power House Two. A new 30,000-kw. generator was purchased for unit No. 10.

A new house turbine has been installed along the wall separating the turbine and boiler rooms. A second unit will be added within a few months, and provision made for additional units later on. These new units are 2000 to 2500 kw. cross-compound condensing turbines operating at 600-lb. steam pressure and provided

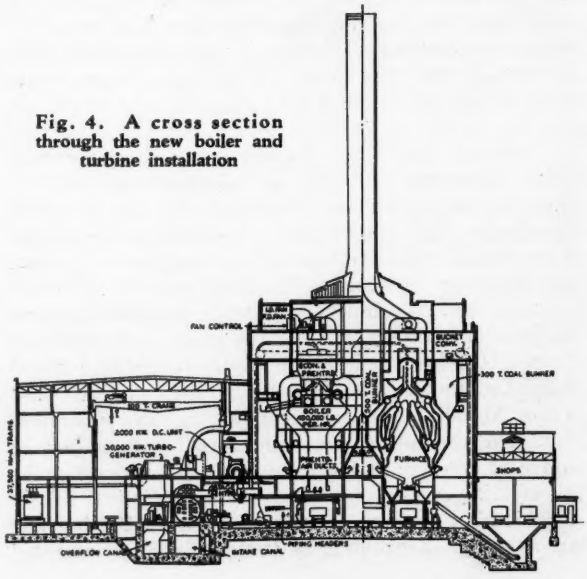


Fig. 4. A cross section through the new boiler and turbine installation

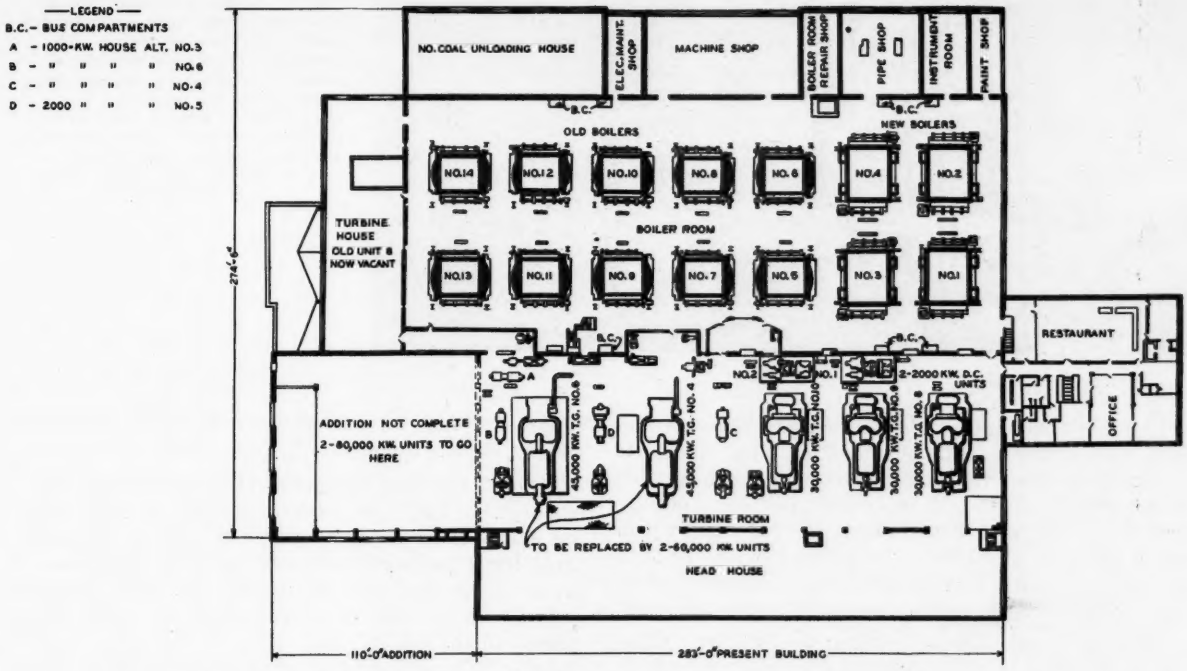


Fig. 5. Plan of station showing the first stage in the revamping program

with bleeder connections for bleeding steam from the outlet of the high pressure unit for building heating in winter. The shaft of the first unit is geared to a single 2000-kw. 240-v. direct current generator. In generating the direct current for house service with these units the present motor generator sets are depended upon principally for stand-by service.

The flow diagram for one of the new units is shown in Fig. 6. Condensate is removed from the main condenser by either of two motor driven lift pumps and delivered to the hotwell pumps which are mounted on the same shafts with the boiler feed pumps. Two of these combination hotwell-boiler feed units are provided, one driven by a turbine and the other by a motor. The lift pumps are interposed between the condenser and the hotwell pumps to eliminate trouble due to cavitation which would be set up by the high speed of the hotwell pumps. From the hotwell pumps the water passes through the 14th and 11th stage heaters, to the boiler feed pumps and then through the 8th and 4th stage heaters to the economizer section of the boiler. Make-up water for the system is supplied by an evaporator, taking steam from the 8th stage bleeder line normally but from the 4th stage bleeder line if desired and the vapor is flashed into the 11th stage heater. The heater drips are cascaded back to the 14th stage heater and pumped into the main feedwater system at a point between the 14th and 11th stage heaters.

The new auxiliary turbines are also connected into the main system as indicated. During the summer months of the year when no steam is needed for heating the building, the auxiliary turbine will operate full condensing. The condensate from the auxiliary condenser is used as circulating water for the air ejector condenser and then delivered to the main condenser or first to a storage tank and then to the main condenser where complete deaeration is effected. In winter, steam will bleed from the high pressure cylinder of the auxiliary turbine into the building heating header. Just enough steam at 10 lb. pressure will be passed to the low pressure cylinder to effect proper cooling. This small amount of steam, about 700 lb. per hr., will not provide sufficient condensate to effect proper cooling in the ejector condenser so a part of the water in storage is recirculated through the ejector condenser, this flow being controlled by a thermostatic element in the outlet of the cooler. The ejector condenser requires about 10,000 lb. of water per hr.

The New Boilers

In the boiler room the changes involved are more complete than in the turbine room for here, with the exception of the stacks and the coal handling equipment, none of the old equipment could be used. The

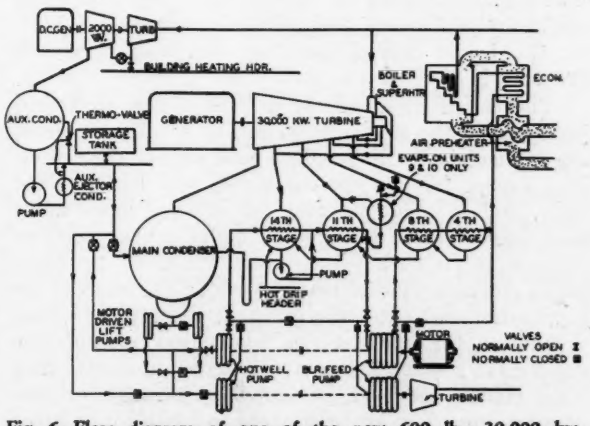


Fig. 6. Flow diagram of one of the new 600 lb., 30,000 kw. generating units

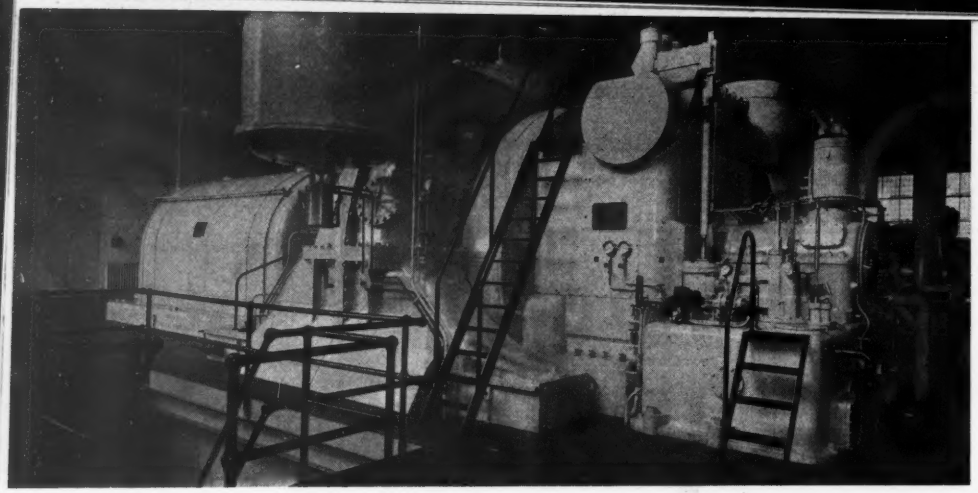


Fig. 7. Turbo generator No. 8, the first of the new generating units to go into operation. This machine consists of a new 600 lb. pressure 30,000-kw. turbine exhausting into the condenser, of the old 20,000-kw. turbine which occupied this location. The generator was taken from an old 225 lb. pressure 30,000-kw. unit in this same station

old boilers were entirely dismantled and removed and new high pressure units installed in their place. It is significant that the new boilers which are capable of producing 330,000 lb. of steam per hour occupy practically the same floor area as the old units which had a capacity of 121,000 lb. of steam per hr. In fact, the new boilers are located on the same column centers and mounted on the same steel work as the old.

The boiler installation is outstanding in many ways, and is the result of many years of experience with various types of steam generating equipment. The double-ended underfeed stokers with which the boilers are equipped were developed from work done at Delray Station. They have a capacity of 32,500 lb. of coal per hr. at normal full load and are designed with a system of metered air control which was developed at the Beacon Street heating plant. The entire control of the boilers is centralized on the operating floor level.

Because of the increased pressure and temperature, new piping was necessary. Throughout, all welding was done by the d.c. metallic arc method. The entire main and auxiliary superheated steam piping systems operating at 650 lb. 850 deg. F. and the boiler feed system which operates in the region of 1000-lb. pressure was welded. In the superheated steam piping there are no flanged joints between the superheater outlet header and the turbine stop valve.

The boilers proper are special double-ended bent tube 6 drum VV type units and having 26,746 sq. ft. of heating surface in the boiler proper. The furnaces are completely water cooled, having an effective bare wall surface of 3114 sq. ft., a Hunter integral block surface of 303 sq. ft. and a furnace volume of 11,000 cu. ft. Under normal conditions the heat release at full load is 39,700 B.t.u. per cu. ft.

The construction of the boilers is best described by means of the cross section in Fig. 8. The elements are symmetrically disposed on each side of the center-line, except for the superheater as will be described later, and so arranged that the furnace gases make four passes before leaving the boiler proper between the drums on both sides. Here the gases converge into a common passage between the two sections of the economizer and enter the latter at the top. Flowing downward through the two economizer sections the gases make a sharp 180 deg. turn to drop the suspended solid matter and then pass upward through vertical counter-cross flow air preheaters and into the induced draft fans. Here the gases from the two sides of the boiler meet and are delivered to the stack, one stack serving each two boilers.

The soot blower arrangement is not evident from the drawing but is of interest because it differs from the conventional system used. Instead of the usual revolving type, stationary soot blowing elements are provided, integral with the boiler. This soot blowing system consists of an arrangement of small tubes welded to the boiler tubes and provided with nozzles suitably disposed so that steam issuing from these nozzles will sweep the boiler tube surfaces. Quick-opening valves, outside the boiler, admit steam. The system is so arranged that all valves on one side of the boiler are opened at once so that the blowing is done in one "puff."

Compensating Type Superheaters

The superheater elements installed in the two halves of the boiler, it will be noted, are different, one (the left side) consisting of a semi-radiant superheater in the first bank of tubes and the other consisting of a similar element in the first bank but also in addition a convection type superheater in the second pass. This compensating type superheater arrangement provides a constant steam temperature of 850 deg. plus or minus 5 deg. over the entire operating range.

In the two gas passages leading to the economizer, it will be noted, there are two sets of dampers. It is by means of these that the steam temperature is controlled. The motor-driven dampers are controlled manually. When the boiler is first started, the damper on the right side is opened wide with the damper on the left nearly closed; thus almost all the gas flows through the right side of the boiler. As the load increases, the damper on the left side is gradually opened allowing more and more gas to flow through that side until finally an equal division is obtained. At this point an interlock trips wide open the damper on the left side and then as the load still continues the damper on the right side begins to be closed. During all this time the temperature of the steam remains constant. This method of steam temperature control is simple and highly effective. The superheater steam temperature is indicated on a large recording pyrometer on the main control board immediately above the controls which operate the dampers.

Automatic Zone Air Control

Perhaps, the most interesting feature of these boiler units, however, is the zone air-control system—forming an integral part of the stoker installation—having for its purpose, the maintenance of a uniform flow of air to each section of the zone under control, corresponding to the boiler load.

Each of the two stokers on one boiler is divided through its width into three zones; these zones known as (1) upper zone; (2) middle zone; and (3) lower zone, the latter more commonly called the extension grate.

Each of these zones is subdivided into twelve retorts—three sections being required for feeding each retort, which consists of one section in the upper zone, another section in the middle zone and still another section in the extension grate, or lower zone.

The entire stoker area of each boiler, therefore, is divided into 72 sections—36 sections to each half of the double ended stokers.

The plenum chamber beneath the stokers is connected with each of these sections by separate Venturi ducts, through which air is supplied by forced draft fans located at the top of the boiler—first having been forced through the air preheater into the ducts running down the side of the boiler into the wind box.

In each of the ducts supplying air for the individual sections is located a damper operated by a hydraulic cylinder which in turn is actuated by a Controller connected to the Venturi throat so that air flow through the duct is metered. This arrangement is clearly shown in Fig. 9.

No matter what stoker is employed, or how perfect the coal feeding mechanism may be, in the very nature of the case there are spots in the fuel bed which ordinarily take more air and hence tend to grow thin, and spots that offer more resistance to the air, and hence tend to grow thick. The Automatic Zone Air Control used in this installation tends to eliminate both because it furnishes the same volume of air to each section at all times, no more and no less—thus insuring a uniform fuel bed at all times.

While each of these Controllers automatically governs its individual section, it becomes necessary under varying boiler loads, to change the rate of flow through each Venturi duct. This is accomplished by six zone regulators—each connected to a group of twelve controllers (constituting the zone) making it possible to advance or retard the flow of air to the six zones; this adjustment being made through a convenient arrangement of handwheels on the central control panel —resulting in loading pressure being applied to the loading diaphragm of each of the twelve air flow regulators, giving the desired rate of flow to that zone.

All of these Controllers are coördinated so that as the rating changes, the volume of air to each section automatically changes—and the amount of change is equal in each section. However, the rate of flow in a complete zone running the width of the stoker can be varied independently of the others—still being controlled automatically.

These six zone regulators also respond to the loading of a Primary Governor as follows; the Primary Governor is connected to a miniature Venturi duct, having a damper in its outlet—exhausting to atmosphere; this Venturi duct having the same characteristics as the larger Venturi ducts that feed the individual sections.

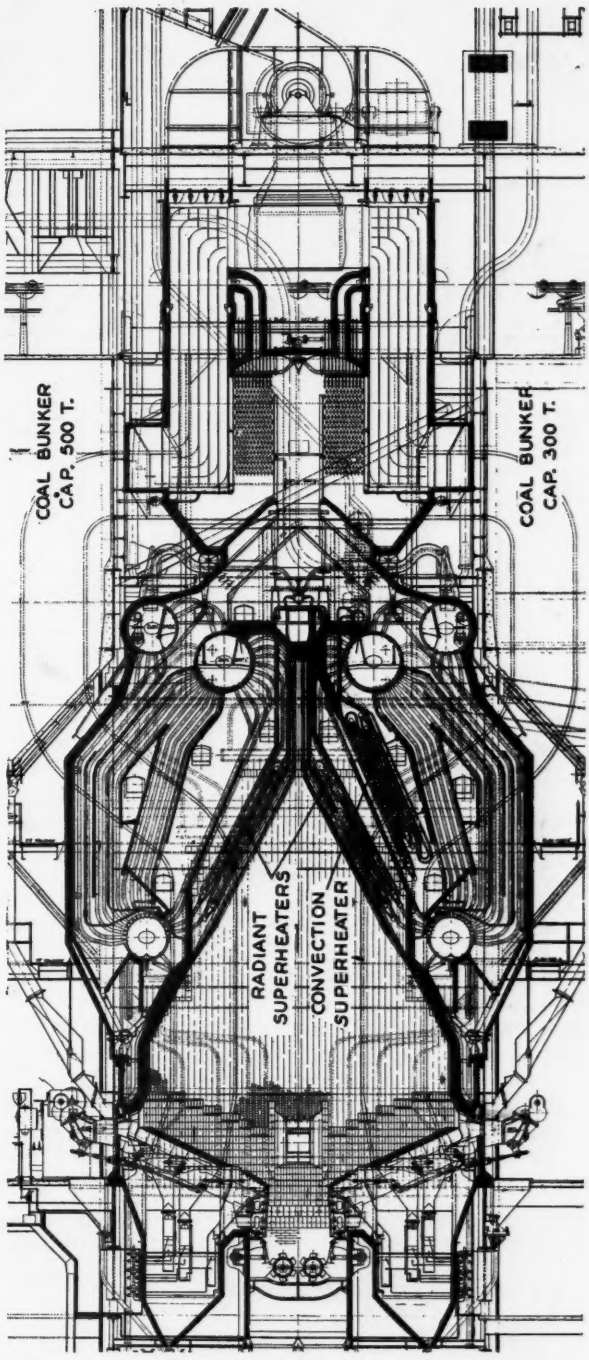
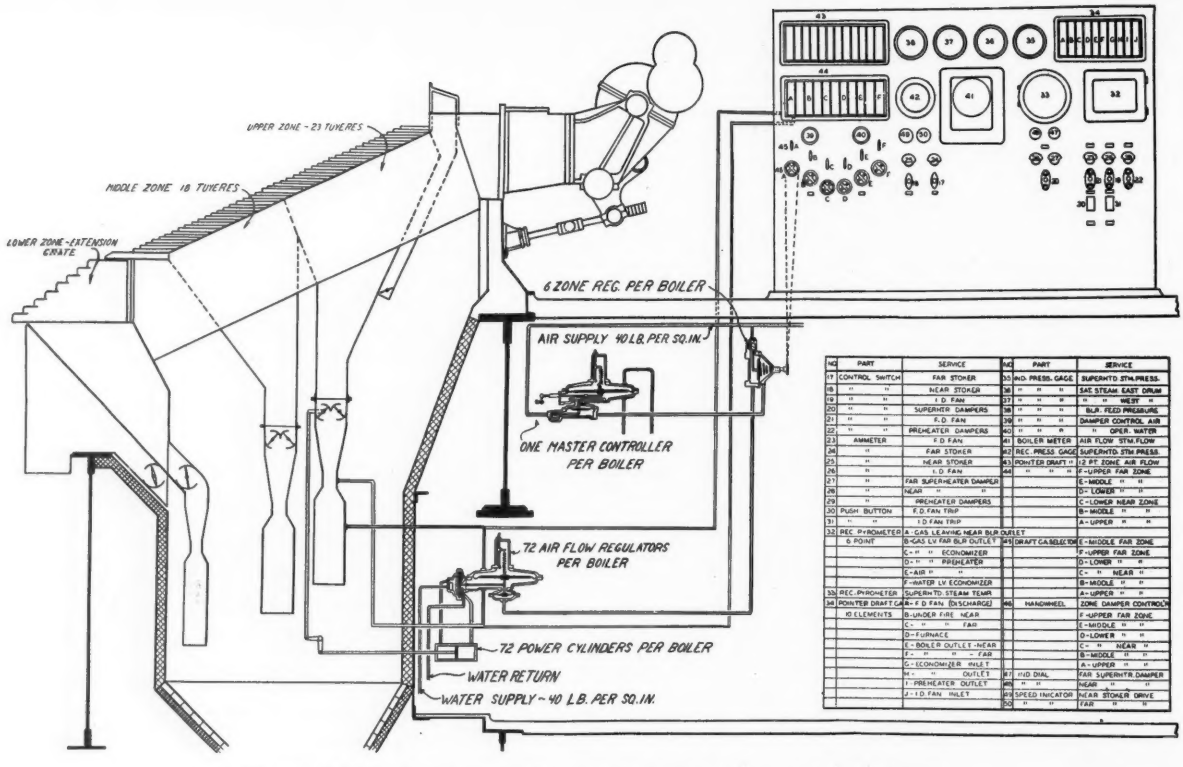


Fig. 8. Sectional elevation through one of the new boilers

As the plenum chamber increases or decreases, according to the boiler load, the Primary Governor automatically varies the loading pressure to each of the six zone regulators; resulting in an increase or decrease of air flow simultaneously through the 72 Venturi ducts.

This control system is located at each end of the boiler underneath the operating floor; the 36 Con-


UPPER ZONE - 23 TUYERES
MIDDLE ZONE 18 TUYERES
LOWER ZONE - EXTENSION GRATE
6 ZONE REG. PER BOILER
AIR SUPPLY 40 LB. PER SQ. IN.
ONE MASTER CONTROLLER PER BOILER
72 AIR FLOW REGULATORS PER BOILER
72 POWER CYLINDERS PER BOILER
WATER RETURN
WATER SUPPLY - 40 L.B. PER SQ. IN.

NO	PART	SERVICE	NO	PART	SERVICE
17	CONTROL SWITCH	FAR STOKER	36	IND. PRESS. GAGE	SUPERHTD. STM. PRESS.
18	" "	NEAR STOKER	38	" " "	SAT. STEAM EAST DRUM
19	" "	I. D. FAN	37	" " "	" " WEST "
20	" "	SUPERHTR DAMPERS	38	" " "	BLR. FEED PRESSURE
21	" "	F. D. FAN	39	" " "	DAMPER CONTROL AIR
22	" "	PREHEATER DAMPERS	40	" " "	" OPER. WATER
23	AMMETER	F. D. FAN	41	BOILER METER	AIR FLOW STM. FLOW
24	"	FAR STOKER	42	REC. PRESS GAGE	SUPERHTD. STM PRESS.
25	"	NEAR STOKER	43	POINTER DRAFT "	12 PT. ZONE AIR FLOW
26	"	I. D. FAN	44	" " "	F-UPPER FAR ZONE
27	"	FAR SUPERHEATER DAMPER			E-MIDDLE " "
28	"	NEAR " "			D-LOWER " "
29	"	PREHEATER DAMPERS			C-LOWER NEAR ZONE
30	PUSH BUTTON	F. D. FAN TRIP			B-MIDDLE " "
31	" "	I. D. FAN TRIP			A-UPPER " "
32	REC. PYROMETER	A-GAS LEAVING NEAR BLR OUTLET			
	6 POINT	B-GAS LV FAR BLR OUTLET	45	DRAFT GA SELECTOR	E-MIDDLE FAR ZONE
		C-" " ECONOMIZER			F-UPPER FAR ZONE
		D-" " PREHEATER			D-LOWER " "
		E-AIR " "			C-" NEAR "
		F-WATER LV ECONOMIZER			B-MIDDLE " "
33	REC. PYROMETER	SUPERHTD. STEAM TEMP.			A-UPPER " "
34	POINTER DRAFT GA	F. D. FAN (DISCHARGE)	46	HANDWHEEL	ZONE DAMPER CONTROL
	10 ELEMENTS	B-UNDER FIRE NEAR			F-UPPER FAR ZONE
		C-" " FAR			E-MIDDLE " "
		D-FURNACE			D-LOWER " "
		E-BOILER OUTLET-NEAR			C-" NEAR "
		F-" " -FAR			B-MIDDLE " "
		G-ECONOMIZER INLET			A-UPPER " "
		H-" " OUTLET	47	MID DIAL	FAR SUPERHTR DAMPER
		I-PREHEATER OUTLET	48	" "	NEAR " "
		J-I.D. FAN INLET	49	SPEED INDICATOR	NEAR STOKER DRIVE
			50	" "	FAR " "

Fig. 9. Details of the automatic zone air control system and meter board

trollers for each half of the stoker being situated on the corresponding side.

Associated with this control is an elaborate array of pressure gages. These are mounted on the main control panel directly above the operating wheels controlling the six zone regulators. Each control board has mounted on it three special differential draft gages. One 12 point gage shows the air flow through the 12 ducts of any one of the 6 zones. Another 6 element differential pressure gage reads the differential air pressure in each of the 6 zones simultaneously, while a third [a 10 point gage] indicates the pressure in various parts of the furnace and gas passages, beginning with the forced draft fan discharge pressure and ending with the induced draft fan inlet pressure. These gages are built with an adjustable screw cam for eliminating the effect of the square root function and giving equal scale divisions so that air flow is indicated directly in cubic feet per minute.

The complete control boards are shown in Figs. 1 and 9. In addition to the draft gages and the zone control equipment, the board contains indicating and recording pressure gages, the boiler meter, recording pyrometers, push button controls for dampers, forced and induced draft fans and stokers.

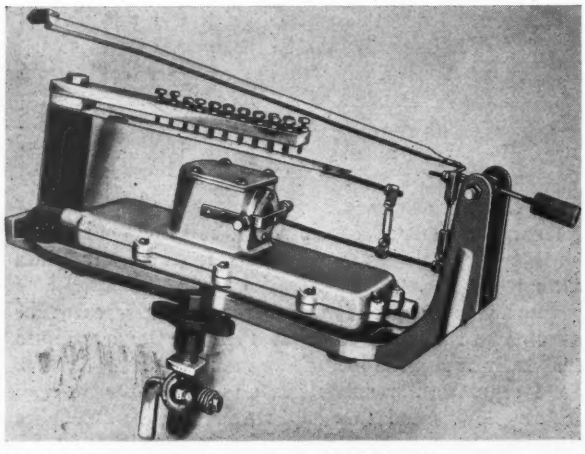


Fig. 10. View showing mechanism of differential pressure gages with adjustable screw cam for eliminating effect of square root function

Original Coal Handling Equipment Retained

As mentioned in an earlier paragraph, the coal handling equipment installed in the original station has been retained. Coal is delivered to the plant by 6000 t. barges though it may also come by rail. From the dock it is loaded into railroad cars by a drag line system and delivered to the plant through track hoppers as shown on the cross section in Fig. 4, to crushers and then to a bucket conveyor system which encircles the boiler house. At the top the coal is delivered to 300 and 500 ton bunkers from which it flows into the stoker hoppers. The stoker hoppers are fitted with conical type coal spreaders.

All motors in the boiler plant are driven by direct current at 240 volts. Since many of the motors are of large capacity the current involved is quite heavy. To carry this current, an aluminum bus system is installed in the boiler room, running vertically

Principal Equipment in New Connors Creek Station

GENERAL DATA

	Old Plant	New Plant
Steam Pressure, lb. per sq. in. gage	220	600
Steam temperature, F.	600	850
Pounds of coal per kw-hr., approx.	1.4	1.0
Boiler efficiency, expected, per cent	78	86
Boiler capacity, lb. per hr.	121,000	331,000
Turbine capacity, kw.	20,000	30,000
Feedwater temperature, F.	190	330
Preheated air temperature, F.		390

BOILER ROOM

Boilers—4 special double ended bent tube, water tube 6 drum "VV" type, 710 lb. gage, 330,000 lb. per hr. at normal full load. 26,764 sq. ft. of surface. Combustion Engineering Co., Inc.

Water Walls—Effective bare wall tube surface, 3114 sq. ft., Hunter integral block surface 303 sq. ft., furnace volume 11,000 cu. ft., heat release 39,700 B.t.u. per hr. per cu. ft. at normal full load.

Superheater—Elesco compensating type, radiant surface 4632 sq. ft. convection surface 6335 sq. ft., steam temperature 850 F. throughout the operating range. The Superheater Co.

Economizers—Two horizontal single-pass counter-flow return-bend fin-tube, total surface 8620 sq. ft. Combustion Engineering Co., Inc.

Air Preheaters—Two Vertical counter-cross flow plate-type surface 28,980 sq. ft., air temperature 390 F. Combustion Engineering Co., Inc.

Stokers—Taylor double-ended underfeed type, 12 retorts, 29 tuyeres, projected grate area 557 sq. ft., coal capacity 32,500 lb. per hr. at normal full load. Westinghouse d.c. motor, 2½-15 hp. 250-2000 r.p.m., 115-230 v.; clinker grinders, two rolls, 20-in. diameter, ⅔ to 9 r.p.h., two General Electric d.c. motors, 250-2000 r.p.m., 5 hp., 230 v. American Engineering Co

Forced Draft Fans—One per boiler, double-inlet Sirocco, capacity 101,000 c.f.m. at 68 F., 15.78 in. water static pressure; Westinghouse d.c. motor, 50-400 hp., 370-740 r.p.m., 230 v. American Blower Co.

Induced Draft Fans—One per boiler, double-inlet two-thirds double-width Sirocco, capacity 181,000 c.f.m. at 346 F., 15.00 in. water static pressure; Westinghouse 230 v. d.c. motor, 88-700 hp, 365-730 r.p.m. American Blower Co.

Feedwater Regulators—Two per boiler, Copes, Northern Equipment Co.

Soot Blowers—Integral type. Diamond Power Specialty Corp.

Safety Valves—Three per boiler. Crosby Steam Gage and Valve Co.

Blowoff Valves—Four per boiler. J. Hopkinson & Co., Ltd.

Water Columns—Four per boiler. Diamond Power Specialty Corp.

Main Steam Valves—The Lunkenheimer Co.

Motor Operators—Cutler-Hammer Co.

Coal Spreaders, Conical Type—Stock Engineering Co.

Zone Air Control, Air Loaded Diaphragm Controller Actuating Hydraulic Cylinder—A. W. Cash Co.

INSTRUMENTS

Special Differential Draft Gages—The Hays Corp.

Flow Meter—Bailey Meter Co.

Pressure Gages—Consolidated Ashcroft-Hancock Co.

Temperature Indicators and Recorders—Leeds & Northrup Co.

Electrical Meters—Weston Electrical Instrument Co.

Tachometer—The Electric Tachometer Co.

TURBINE ROOM

Main Turbines**—30,000 kw., 1 two-row Curtis, and 17 single-row stages, bled at 4 points, 1800 r.p.m. General Electric Co.

Main Generators*—37,500 kv.a. at 0.8 power factor, 1800 r.p.m., 12,200 v., direct-connected exciter, 140 kw., 250 v. General Electric Co.

Main Condensers*—Two pass, 27,000 sq. ft. Worthington Pump & Mach. Corp.

Main Circulators*—One per condenser, 42-in. volute pump, 36,000 g.p.m.; General Electric d.c. motor, 200-250 hp., 280-375 r.p.m. Worthington Pump & Mach. Corp.

Main Unit Dry Vacuum Pump*—One per condenser, Laidlaw-Dunn-Gordon two-stage single acting type; General Electric d.c. motor, 30-100 r.p.m., 12-40 hp. Worthington Pump & Mach. Corp.

Oil Coolers*—Duplicate, Schutte-Koerting vertical.

Oil Filtration*—Portable equipment, De Laval Separator Co.

Generator Air Coolers*—1682 sq. ft. General Electric Co.

Auxiliary Turbine—2150 kw., cross-compound; HP turbine, 4996 r.p.m., 600 lb. per sq. in., 825 F., 10 lb. per sq. in. back pressure; LP turbine, 3622 r.p.m., 1-in. Hg. back pressure. General Electric Co.

Auxiliary Generator—2000 kw., 240 v., 450 r.p.m., direct current. General Electric Co.

Auxiliary Condensers—Two pass, 2200 sq ft. welded shell. Worthington Pump & Mach. Corp.

Auxiliary Circulator—One per condenser, 17½ in. split case volute pump, 21 ft. head, 2700 g.p.m., Westinghouse d.c. motor, 15-25 hp., 450-900 r.p.m. Worthington Pump & Mach. Corp.

Auxiliary Unit Dry Vacuum Pump—Special twin-element, two-stage steam air ejector with inter and after cooler, steam consumption 150 lb. per hr. Worthington Pump & Mach. Corp.

FEEDWATER SYSTEM

Stage Heaters—Two horizontal high-pressure four-pass condenser type with desuperheat zone, water pressure 1000 lb. per sq. in., feedwater 320,500 lb. per hr. two horizontal low-pressure four-pass condenser type, water pressure 200 lb. per sq. in. Foster Wheeler Corp.

Storage Tank—Welded-steel construction, 40,000 gal.

Pumps—Combination boiler feed and hotwell, two per main unit; boiler feed pump, 647 g.p.m., 1790 ft. head; hotwell pump, 608 g.p.m., 284 ft. head; motor-driven unit, Westinghouse 4800-v., 3-phase a.c. slip-ring motor, 101-505 hp., 1412-1780 r.p.m.; turbine-driven unit, 550-hp., 1780 r.p.m. DeLaval Steam Turbine Co.

Lift Pumps*—Two per main unit, 600 g.p.m., 140 ft., head; General Electric d.c. motor, 35 hp., 1200 r.p.m. Worthington Pump & Mach. Corp.

Heater-Drain Pumps—One per main unit, 203 g.p.m., 440 ft. head; Westinghouse d.c. motor, 22-50 hp., 1620-1830 r.p.m. DeLaval Steam Turbine Co.

Hot-Drip Pump—200 g.p.m., 100 ft. head. Westinghouse d.c. motor, 900-1800 r.p.m., 5-10 hp. Pennsylvania Pump & Compressor Co.

Auxiliary Unit Hotwell Pump—One per unit, 65 t.p.m., 135 ft. head, 1750 r.p.m., Westinghouse d.c. motor, 7½ hp., 1750 r.p.m. Worthington Pump & Mach. Corp.

ELECTRICAL EQUIPMENT

Circuit Breakers—Type FH-209-C, 600 and 3000 amp. 35 kv. circuit breakers, 40,000 amp. interrupting capacity, solenoid-operated, each phase inclosed in metal housing. General Electric Co. Deion breakers, same rating. Westinghouse Elec. & Mfg. Co.

Main Bus—Two 2-in. double-extra-heavy copper tubes per phase, rated 2700 amp. at 35 deg. C. rise, each phase inclosed in metal housing.

Breaker and Bus Housings—Aluminum for heavy currents, steel for light currents, sectionalized and insulated from building and from adjacent sections.

Relays—For Bus Fault Protection—Instantaneous, overcurrent type PQ 29Y2, General Electric Co.

For Generator Differential Protection—Ratio-differential, type CA, Westinghouse Elec. & Mfg. Co. Also Instantaneous, overcurrent, type P. Q. General Electric Co.

For Parallel Feeder Protection—Balanced-current, type PD 3, General Electric Co. Also Time-delay, overcurrent, type PQ 1 Y2, General Electric Co.

For Radial Feeder Protection—Combined instantaneous and inverse time, type RI. Condit Electrical Mfg. Co.

Control Wiring—Armored, lead-covered, multiple-conductor, control cable mounted on racks in runway. The Okonite Company.

Switchboard—Steel, cabinet type, Benchboard style for generator and section breaker controls and panel type for feeder control and relays.

Test Equipment—150 Kv., Kenetron, cable testing set with distribution system. General Electric Company.

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* Denotes old equipment re-used with or without alteration.

** New Main Turbine includes exhaust casing, pedestal bearings, oil base, parts of governor and atmospheric relief valves from old 20,000 kw. unit.

up the boiler room wall to the forced and induced draft fans and coal handling equipment. This bus system presents a simple and neat arrangement and has proved very convenient.

The direct current auxiliary system employed at this station is one that has given excellent satisfaction throughout the years that the station has been in service. It provides a degree of speed control of the auxiliary motors that could not be attained by alternating current motors except by the use of complicated and expensive equipment. The direct current motors are reliable and efficient and the control simple. With the elimination of the motor generator sets by the provision of the new direct current house turbo-generators, the system will be simplified and at the same time rendered slightly more efficient.

In concluding this article brief reference should be made to the electrical features. Originally, the electrical equipment was installed in the same building with the boilers and generators, but now the buses and switching apparatus is housed in an entirely separate building, located several hundred feet from the main station, known as the Essex Switching Station. The new equipment involved in this structure includes new circuit breakers of increased capacity together with buses, relays, control and testing equipment. A list of the new electrical equipment involved is shown in the accompanying list of equipment.

Program Load Control for Turbines

Colfax Power Station Turbo-Generators Are Automatically Loaded According to a Predetermined Schedule. Installation of Control Equipment Justified by 3 Yr. Experience.

By T. E. PURCELL

General Supt. of Stations
Duquesne Light Co., Pittsburgh, Pa.

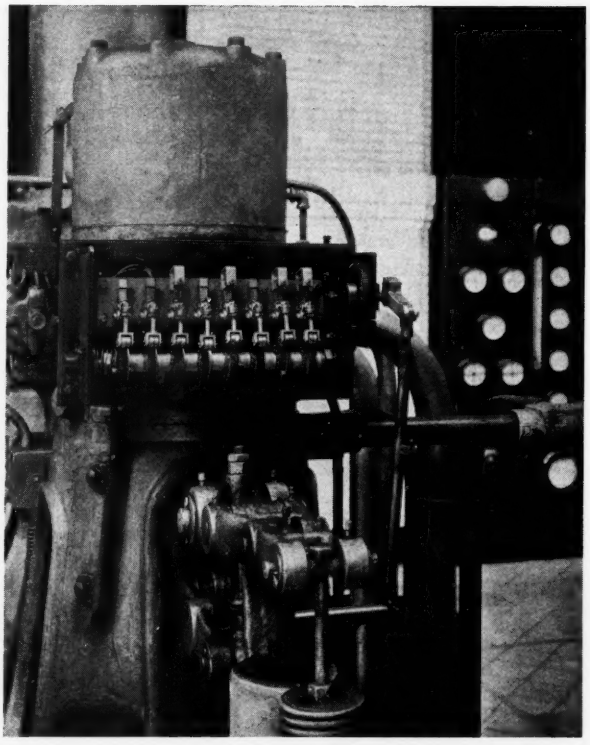


Fig. 1. Cam switch, mounted on turbine, with the contacts set to indicate the maximum and minimum valve position

PROBLEMS OF ALLOCATING most advantageously the load among the several stations or generating units of a power system has been given a fair amount of study during the past few years. Few operators have, however, pursued their work to its logical conclusion. All agree that load should be distributed among the power units in accordance with a prearranged economically correct schedule, but leave it to the station operator to make such distribution manually. The best results may not be obtained in this manner.

Believing that a much more satisfactory and economically correct job could be done by automatic control, we have developed equipment for this purpose. This equipment, known as "program load control," has been in most satisfatory service at the Colfax Power Station of the Duquesne Light Co. for several years.

Program load control is a device which controls the load distribution of several turbines according to a prearranged schedule thereby eliminating the errors in load distribution that exist with intermittent hand control. It is designed to operate in conjunction with automatic frequency and load regulators in such a manner as to eliminate the divergence from the load schedule which usually results from the application of these automatic controls.

The basis of load distribution between several turbines in a power station or between several power stations is the relative increment heat rates of the several turbines or of the stations in question. The load schedule at the Colfax Power Station is based on the increment heat rates of the turbines. It was found that for operation within a given valve range, the increment heat rates were approximately constant and that these increment heat rates had sufficient divergence to enable the valve position to accurately indicate the relation between the increment heat rates of the turbines.

It is the practice at Colfax to load the turbines by valve position as different output schedules were required to correct for differences in vacuum when kilowatt output is used for the load schedules. This method is quite accurate as the circulating water temperatures for a given station will vary uniformly on all units and as the load distribution within a station depends not on the absolute increment heat rate but on the relative heat rates as indicated by the valve positions.

Electric Clocks Influence Control

The rapid increase in use of synchronous electric clocks has made necessary control of the integrated speed error, or time error, within close limits. Automatic frequency regulators are applied to hold a more uniform system speed thereby reducing the accumulated time error and also to reduce the necessity of continued effort by the station operator to accomplish proper speed control by manual means.

Ordinarily when automatic frequency control is applied, one or more units are assigned to automatic regulation forcing all of the system load changes on these units, then as the load changes accumulate, the load is transferred manually to or from other units or stations in order to approximate the ideal load distribution. When viewed only from the angle of time or speed control, this method is satisfactory as it accomplishes the purpose for which most automatic frequency regulators are installed. In many cases, however, it violates the economic loading schedule introducing

errors which, through decreased station economy, are expensive and in light of our experience, unnecessary. It is, therefore, desirable to provide equipment to distribute load changes in a manner that will not result in loss of station economy due to loading errors.

Requirements

Many schemes have been tried to determine the most desirable method of loading a steam station having automatic frequency control. The usual methods of control are as follows:

1. Automatic frequency control on one unit. This unit being held within its assigned maneuvering range by manually transferring load to or from other units.
2. Automatic frequency control manually selected to all units, control being transferred by the station operator in accordance with the load schedule.
3. Automatic frequency control on one master unit. Load control on one or more units matching load of master unit in proportion to unit capacities.
4. Frequency control on several units with load on regulated units directly proportional to accumulated time error.

These schemes have the following disadvantages:

SCHEME No. 1. Requires close manual supervision and otherwise unnecessary generating capacity must be operated to provide maneuvering range.
SCHEME No. 2. Requires very close manual supervision.
SCHEMES Nos. 3 and 4. Gives satisfactory economy only when all of the regulated units have the same increment heat rates.

After thoroughly analyzing and using several of these schemes in trial operation, it was decided that none of them could satisfactorily provide those features which seem desirable in an automatic load control for the load schedule at Colfax.

The control should:

1. Operate in conjunction with frequency, tie line, load or manual control.
2. Accurately distribute the load changes over the operating units in accordance with the prearranged load schedule.
3. Permit grouping units of equal increment heat rates so as to share load changes on such units equally.
4. Provide simple means for adjusting the load schedule.
5. Provide means to omit any unit from loading sequence when out of service or on special loading.
6. Provide continuous control with partial capacity, eliminating dead spots in control range.
7. Provide means for load regulation on one unit only without regard for load schedule, when desirable.
8. Provide means for checking load schedule and correcting load deviations without forcing load changes on system.

The control should not:

1. Interfere with normal speed control by the speed regulating governor.
2. Interfere with normal governor action during system disturbances.
3. Vary the load on any one unit above or below the full load or minimum load limits. The minimum load limit is usually set at about 15% of the machine rating and full load is the nameplate rating. (All overload operation is accomplished by manual control.)

Our program load control as installed at Colfax meets all of these conditions. It is a combination of the following devices:

1. Cam switches and contacts mounted on the turbine as shown by Fig. 1, actuated by the valve mechanism and set to indicate the maximum and minimum valve positions for a definite increment heat rate range.
2. A selector switch shown by Fig. 2, to route the "raise" and "lower" impulses originated by the frequency or tie line regulator to each of the regulated turbines, one at a time.
3. A sequence panel which by means of a plug and jack arrangement, permits the horizontal rows of the selector switch contacts being connected to the governor speed control motors and valve position cam switches in the order required to reproduce the load schedule. This is shown at the left of Fig. 2.
4. Auxiliary devices to guide the operation of the program load control.
   - A. Master "raise" and "lower" load impulse push buttons. A of Fig. 3. These push buttons are used for manually changing station loading.
   - B. Maximum and minimum load schedule reset push buttons. B of Fig. 3. These push buttons move the selector switch to either the full load or no load position thereby enabling it to pick up units that have just been added to the operating capacity and which are placed in service at minimum load.
   - C. Turbine skip switches used to bypass turbines operating off schedule or bypass turbines not in operation. C of Fig. 3.
   - D. Valve position indicator lamps to indicate the valve range in which each turbine is operating. D of Fig. 3.
   - E. Load impulse lamps to indicate the duration and direction of the corrective impulses on each turbine. E of Fig. 3.
   - F. Parallel operation switches to load duplicate pairs of turbines simultaneously. This doubles the rate of load response for unusual load conditions. F of. Fig. 3.

Operation of the device is as follows: with the selector switch on the top row of contacts the circuits to the governor speed control motors and from the valve position switches are completed to the top sequence jack, shown in Fig. 2. The plug completing the connections to the turbine having the first valve range on the load schedule is inserted in this sequence jack. The plug for the turbine having the second valve range occurring on the load schedule is inserted in the next sequence jack. The third and succeeding plugs are inserted in the sequence jacks in the order of valve ranges specified by the load schedule.

Skip switches for the operating turbines are then turned to the operating positions thereby arranging the selector control motor circuit in such a manner that the closing of the maximum limit switch for the first valve

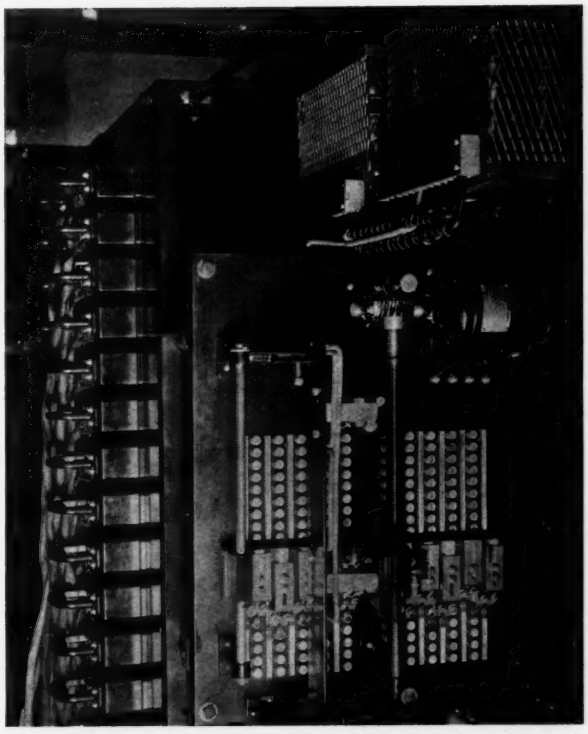


Fig. 2. Selector switch and sequence panel. The selector switch is in the right foreground and the sequence panel on the left

position and a "raise" load impulse from the frequency regulator moves the selector to the next row of contacts completing the control circuits to the turbine having the second valve position on the load schedule. When the load on this turbine has increased closing the maximum valve contact the selector switch is again advanced to the next row of contacts progressing in this manner to the last valve position for full station load. The action when lowering the load is similar except the minimum valve load contacts and "lower" load impulses are required to move the selector back each row of contacts.

In event of abnormal system disturbances the governors on all operating units may admit more or less steam to all turbines. This upsets the load schedule temporarily, but during such condition it is essential to distribute the load over all the operating units thus

taking full advantage of the governor action to maintain the system rather than attempt to follow an ideal load schedule. During a disturbance of this nature, the selector switch will continue to distribute the load changes originated by the action of the automatic control in accordance with the load schedule although the governor action will cause deviations from the load schedule.

As the system speed becomes normal, the governors return to their original position and the selector switch continues to distribute the load changes in a manner that eliminates all of the temporary load errors. If the abnormal load distribution is to remain on the system for a period of time, the selector is moved by means of the reset push buttons to the lowest increment heat rate and the first "raise" impulse of the frequency or load regulator will move the selector switch to the first turbine operating off the load schedule thereby correcting the load schedule as the station load changes.

Interlocks

There are several interlocks used to prevent conflict between the operators and the control. All the manual governor speed control motor switches have

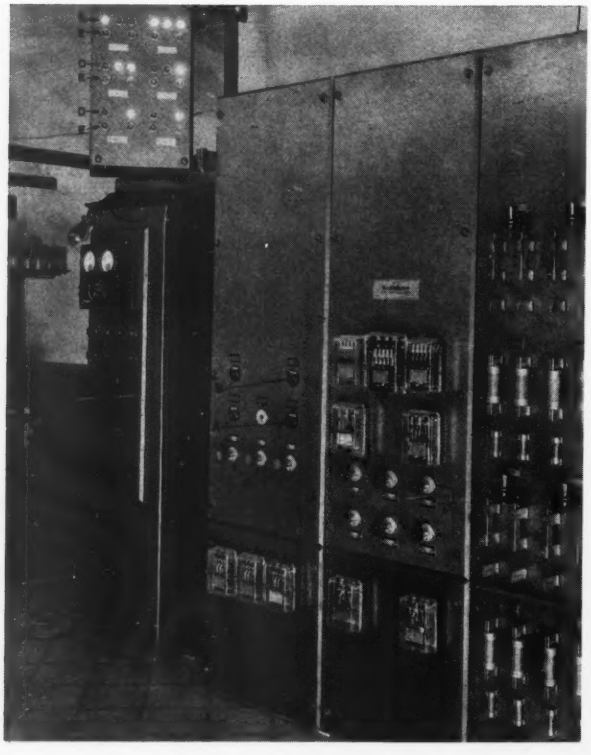


Fig. 3. Front view of program load control panels. A. "raise" and "lower" impulse push buttons. B. Maximum and minimum load schedule reset push buttons. C. Turbine skip switches. D. Valve position indicators. E. Load impulse lamps. F. Parallel operation switches

interlock contacts in the "off" position which complete the Program load control circuits to the governor speed control motors. These contacts are broken before the manual controller can be turned to the "raise" or "lower" position. The duration of the impulses to the governor motors is limited by timing relays which lock out the control when a long impulse is observed, preventing abnormal load changes which may result from a sticking contact or stalled regulator. The control is also locked out when the frequency deviation is more than plus or minus 0.25 cycles.

Program load control has justified its installation during three years' service at the Colfax Power Station because:

It has held the load distribution more nearly to the schedule than could have been done manually.

It has decreased the effect of wire drawing at the valves due to more accurate setting of the maximum and minimum valve positions, with a resultant decrease in valve maintenance.

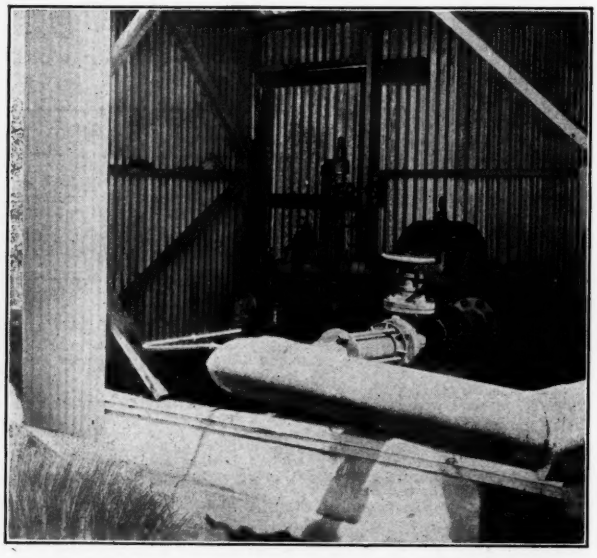
It has greatly reduced the attention required of the station operators to hold the load schedule when using automatic frequency control.

It has made possible the reduction of valve lap giving greater load capacity on each valve with a resulting gain in economy.

It has greatly improved the speed regulation by assigning the increment load changes to the proper turbine, eliminating the load change to correct the loading error which results when one turbine is on automatic load control and the remaining turbine on manual load control.

Natural Gas Turbine

OPERATING on natural gas, a 45 hp. Elliott turbine drives a centrifugal water pump supplying water for the plant of the Athletic Mining & Smelting Co., Fort Smith, Ark. The turbine acts as a reducing

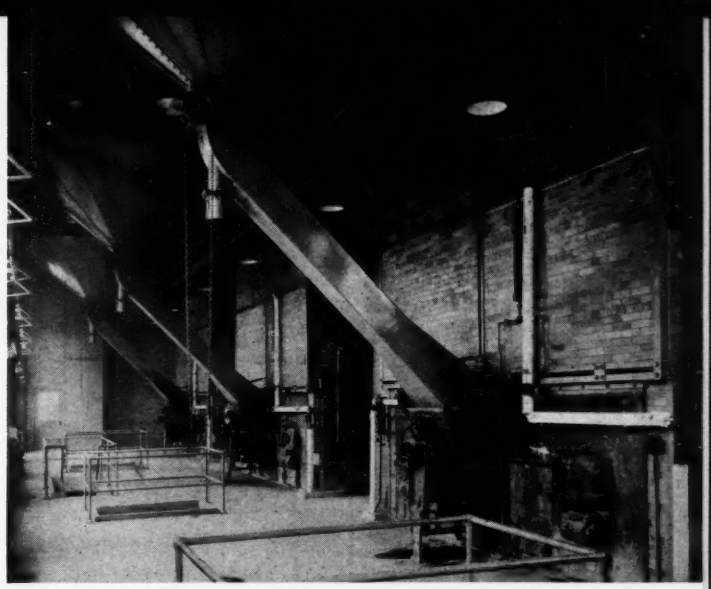


This 45 hp. turbine operates on natural gas

valve, and exhausts low-pressure gas for plant consumption. Gas pressure ranges from 40 to 50 lb. ga. and the exhaust from the turbine enters the low-pressure gas main at about 8 lb. ga. pressure. The gas now passing through the turbine represents about two-thirds of the gas now needed for the operation of the plant.

Combustion Control

Part III. Steam Pressure and Furnace Draft Regulators. Individual and Master Controllers



FOR PRACTICAL PURPOSES and simple installations, the combustion control must operate to maintain the steam pressure nearly constant by proportioning the fuel feed and air supply to the steam demand, and, with forced draft, maintain the desired furnace pressure as well. The steam flow, as indicated by a change in pressure from normal, supplies the initial impulse to set the regulating equipment in motion and the furnace draft the secondary impulse that establishes equilibrium after a change has been made.

The simplest application would be a hand fired natural draft boiler in which case the only element subject to control would be the draft as controlled by the stack or outlet damper. In this case a steam pressure regulator would be attached to the damper and regulate its position in accordance with the steam demand. With natural draft stoker, gas or oil firing, the function of the steam pressure regulator might be extended to include the fuel feed as well as in Fig. 1. In this case the furnace draft must of necessity increase with the load in order to draw in sufficient air for combustion and the furnace pressure regulator, as shown, would not be needed.

With forced draft, however, the amount of air entering the furnace is normally controlled by the forced draft pressure and the furnace pressure is maintained at or slightly below atmospheric pressure. This is usually accomplished by adding a furnace pressure regulator as in Fig. 1. The controls are not, of course, always arranged in the same way. Many combinations of controlling the forced draft, fuel and induced draft are in service using the same two regulating elements, the steam pressure regulator and the furnace pressure regulator.

Both of these regulators are built in a variety of designs which will be described in detail later. In general, the steam pressure regulators are of the weighted-lever arm diaphragm type built on the principle of the old yard arm. Steam acting on a diaphragm tends to move a pivoted lever arm loaded with weights. The regulator might be used in this simple form by attaching the device to be moved directly to the end of the lever arm but for moving dampers considerable power is required, and it is customary to have the lever arm move only a small pilot valve which in turn controls the flow or pressure of water, oil, steam or air to an operating cylinder.

By changing the size of the diaphragm and the operating cylinder the regulator may be made as sensitive and powerful as desired. For some purposes where the speed of response is rapid such a regulator would be satisfactory. In the case of a damper, however, there is considerable lag in the system and after the change in steam pressure is detected by the regulator and the damper position changed, there is an appreciable time interval before the effect of the changed position influences the steam pressure. Under these conditions an increase in steam pressure would displace the pilot valve and the operating piston would take a full stroke before the regulator arm moved the pilot valve back to neutral position. The damper, therefore, would be closed completely, the pressure would drop, the pilot valve would be displaced to the opposite side and the operating piston would open the damper wide. With a full stroke regulator of this type the damper would always be changing from one extreme to the other.

To eliminate this hunting action a compensator or stabilizer may be added. An increase in pressure will move the pilot valve as before, but as the piston rod moves down the pilot valve is forced back to its neutral position. With the pilot valve in its neutral position the piston is locked until another change in steam pressure takes place to again move the pilot valve from neutral. A large change in pressure will displace the pilot valve farther from neutral than a small pressure change and this means that the operating piston must travel a greater distance before the compensator returns the pilot valve to its neutral position.

The piston will, therefore, take a definite position for each pressure change from normal. In practice the regulators are adjusted to give a full stroke of the piston for a definite pressure change, say 5 lb., from normal. That is at say 150 lb. pressure the piston would be at the bottom of the cylinder and the damper would be closed while at 145 lb. pressure the piston would be at the top of its stroke and the damper would be wide open. It is in the design or arrangement of the compensator that the various makes of regulators differ most. Some of the compensators act to move the weights on the lever arm, some have springs and some use cams or eccentric pulleys to get the action necessary to lock the piston in position until changes in the furnace are reflected by the steam pressure.

All regulators are sensitive but they are not all made the same way. Some will move the damper a small amount with each small pressure change so there is an infinite number of piston positions. Others require a definite pressure change or step before the piston is moved so that the piston positions are limited, to say ten, as fixed by the design of the regulator. These steps may or may not be uniform. The operating cylinders may be single or double acting vertical or horizontal.

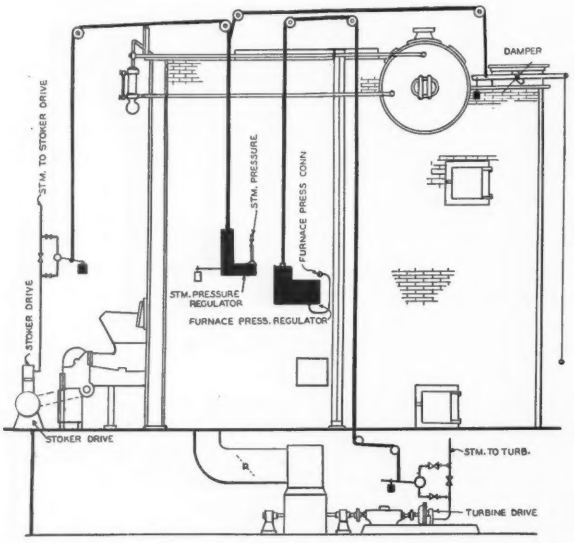


Fig. 1. An arrangement where the steam pressure regulator controls the outlet damper and fuel feed and the furnace pressure regulator the forced draft

Furnace pressure regulators in general use the same type pilot valve, operating cylinder and compensator, and, although a diaphragm is sometimes used, the sealed ball type is perhaps more common. Any change from the normal pressure will tend to tilt the bar on which the bells are suspended and displace the pilot valve to open or close the damper as the case may be.

Detailed design and operation of a number of makes will be taken up in the next article. The two mentioned are known as the hydraulic type, that is, the power is supplied by hydraulic cylinder using air, water, oil or steam as the operating medium. Electric regulators are also used and may be of the same general design except that the pilot valve is replaced by electric contacts and the operating cylinder by an electric motor. This type may also be compensated.

As shown by Fig. 1, the regulators are used with a single boiler. With a number of boilers each boiler might be equipped with individual regulators or a single steam pressure regulator may be used to control several boilers. This is not the case with furnace pressure, however, and an individual regulator is always used because the furnace pressure requires much more delicate regulation, which must be in accordance with the demands of a particular boiler and although such regulation is extremely important to that boiler, it is of secondary importance to, and follows, the demand for steam as evidenced by the steam pressure.

When a single steam pressure regulator is used for several boilers it is commonly called a master regulator. The master regulator may exercise this control in a number of ways, the most obvious being direct control by cable, links or shafts. One such arrangement is shown by Fig. 2. Here one steam pressure regulator controls the outlet dampers and the fuel feed of several boilers and in addition has a partial control of the forced draft. Final control of the forced draft fan is under the furnace pressure regulator, however, in order to compensate for unequal fuel feed to the furnace.

Of recent years other methods, electric and hydraulic, have been developed to use with master regulators controlling a number of boilers. These systems differ widely in principle and operation but are built to meet the triple requirements of maintaining header steam pressure, dividing the load between the boilers and holding the desired air and fuel ratio for each boiler.

Of these, the electric systems changing the voltage or sending a series of impulses by making and breaking the necessary contacts are the easiest to visualize but the hydraulic systems are perhaps more common. The hydraulic systems usually employ air or oil and the pressure in the system is controlled by the master regulator in accordance with the steam demand. The fluid pressure in turn controls the individual boilers through suitable operating cylinders. The variety of controls used make it impossible to generalize on these systems which will be covered individually in later articles.

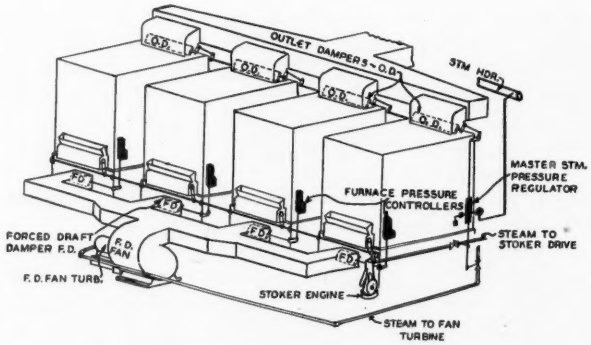


Fig. 2. One pressure regulator controlling the induced draft, forced draft and fuel feed on several boilers, each boiler having an individual furnace pressure regulator for close regulation of forced draft

The steam pressure regulator and the furnace pressure regulator are, however, fundamental parts of all combustion control systems and are often of the diaphragm and sealed bell types. The individual control systems differ primarily in the design of the regulators, pilot valves, operating cylinders and compensators and in the way in which the action of these primary devices is transmitted to the equipment they control. The purpose of subsequent articles is to tell how the individual pieces of equipment work and how their action is coördinated by the different combustion control systems.

Protection *of* Spare Boilers *from* Internal Corrosion

Dry Storage with Lime Recommended for Long Periods, Wet Storage for Short Periods. Use of Ammonia Gas and Sodium Sulphite Suggested to N.D.H.A. Engineers by Harold Farmer, Chemist of Philadelphia Electric Co.

DATA ON THE SUBJECT of laying-up boilers are conspicuous by their absence even though it is one that should be given careful consideration. Most steam plants probably found that it was necessary, during the last 2 yr., to lay up more boilers than heretofore and that a definite procedure to insure protection from corrosion during the lay-up period would have been desirable.

The writer is not attempting to lay down any definite procedure for laying up boilers, but, by presenting some of the difficulties encountered and reviewing some methods employed, bring about constructive criticism. Such criticism may lead to development of what might be considered good practice and result not only in considerable saving in maintenance, but in providing continuity of service by having boilers ready for immediate service.

For the present, consideration is given only to the procedure for protecting the inside of the boilers and appurtenances. The necessity for protection of the outside of the boiler and equipment should, however, not be overlooked.

It appears that the consensus of opinion is in favor of draining the boiler when it is to be laid up indefinitely. When a boiler is to be out of service for one month or less, draining does not appear to be justified and for the purpose of protecting the metal under these conditions some definite chemical procedure should be followed.

Dry Storage Best for Long Periods

The following procedure for laying up boilers has been recommended by a well-known manufacturer: Boilers held out of service must be carefully handled and closely watched in order to minimize any tendency for internal corrosion. When it is known that a boiler will be stored for a considerable length of time, and allowance can be made for a brief period of preparation for demanded service, the dry storage is recommended. In this method the unit is emptied, thoroughly cleaned internally and externally, dried, and then closed up tight to exclude both moisture and air.

Trays of lime may be placed in the drums to absorb the moisture in the air trapped by the closing up of the boiler. Particular care must be taken to prevent water, steam, or air leakage into the unit. Periodic inspections should be made to insure that no corrosive action is taking place and that lime is replenished upon signs of deterioration. The same general method of preparing the boiler for out-of-service periods should be followed for the superheater, economizer, and reheater sections.

Where boilers are to go into stand-by service and must be held ready for sudden calls for operation, they should be steamed in service in order that boiler water conditions may be stabilized and oxygen bubbles cleared from the boiler surfaces. The boiler should be brought down in rating slowly and water level raised as high in the glass as is consistent with safe operation while still unloading some steam to the line. The lowed for the superheater, economizer and reheater.

When the pressure as shown by the boiler vent has practically disappeared, but before a vacuum due to cooling off is produced, the boiler should be slowly filled completely full so that spill-over and filling of the superheater is accomplished. This make-up water must be deaerated and should also carry the minimum alkalinity of 20 gr. per gal. The drain on the boiler side of the main steam stop valve should be checked open so that any water getting past the non-return valve will not accumulate on the boiler side of the stop valve. Filling should continue until a pressure of at least 10 lb. against the non-return valve is evident. Close watch should be kept by the operators to guard against building any undue pressure against the non-return valve due to leaking feedwater valves.

Boiler connections should be checked for leakage and frequent boiler water samples should be taken to guard against diminution of alkalinity. Such loss should be compensated for through injection of a dilute solution of caustic soda through the feed connection by means of a hand pump or by some similar and convenient method. Even with the above precaution the danger of possible corrosion must not be underestimated and no boiler should be held in wet storage without emptying for periodic inspections.

When boilers are called upon for intermittent steaming on such short notice that even the wet storage method as described above cannot be used, the possibility of corrosion is greatly increased, and some additional protection may be obtained by the use of several grains per gallon of sodium dichromate.

Superheaters, during out-of-service periods, except when the complete wet storage method is used, should always be kept dry, and closed from contact with the air. Reheaters should be taken care of the same as superheaters except that the wet storage method would not be used. No unit should be wet stored when there is any probability that the temperature will drop to the freezing point.

Settings should be kept closed, but inspections should be made regularly to guard against sweating and corrosion of the external surfaces of the pressure parts and the other exposed metallic surfaces. It may be found necessary to use coke jacks or similar heating stoves at convenient points during protracted spells of damp weather accompanied by a rising temperature.

Ammonia Used in Germany

From Germany comes the recommendation to use ammonia gas when a boiler is to be laid up for a considerable period of time: Steam boilers, which must remain out of service for a considerable period of time, may be protected from rust by filling them with gaseous ammonia, according to the experience of the Merseburg ammonia works of the I. G. Farbenindustrie. The idle boiler is emptied and carefully dried out, then filled with ammonia gas from a steel cylinder and closed hermetically. Ammonia reacts with the remaining moisture and forms a rust proofing agent. The dry parts are, of course, sufficiently protected. When the boiler is to be placed in service again it is completely filled with water to drive out all of the gas. Then the excess water is removed and the unit is ready to be fired.

The practice followed in large central station plants with which the writer is more familiar, has been that when boilers are to be laid up for two months or longer, to empty the unit, clean and dry, placing trays of lime in the drums, and closing up the boilers. This procedure appears to be used generally by many companies. It is possible to dry the drums manually and maintain them dry by the use of lime. The water tubes and superheater tubes, however, cannot be so successfully dried and have to rely upon the moisture absorption from the air by the lime trays in the drums. It is quite possible that many boilers so conditioned may suffer corroded tubes due to inability to dry the tubes properly.

Laying up boilers "wet" for intermittent service and for short periods appears to have many advantages over the dry method, provided that proper precautions are observed. It is the writer's opinion that boilers could be laid up "wet" for indefinite periods if proper precautions are observed. The chief objection to this being where freezing temperatures are encountered.

It has been observed that boilers laid up "wet" and with sufficient alkalinity present to give a pH value of 11.0 frequently show signs of rusty water when sampled. This is probably due to incomplete deaeration of the water before filling the boiler.

During the last two years the use of sodium sulphite has received considerable attention for use in boiler water for the purpose of removing the small quantities of oxygen left in the feedwater. Many investigators have reported on the successful use of this reagent. Sodium sulphite in combining with the dissolved oxygen present in the water produces sodium sulphate. There is a decided advantage in this reaction since sodium sulphate is generally required in the water to maintain the proper A.S.M.E. ratio.

The writer has investigated the use of sodium sulphite with boiler waters in two steam heat stations with boiler pressures of 125 lb., 100 per cent raw water make-up and feedwater temperatures of 205 and 180 deg. F. respectively. The boilers in these plants showed rusty water even when high alkalinities were maintained and when banked for a few days there was a marked increase in the rusty condition of the water.

Small quantities of sodium sulphite added to the feedwater has stopped the rusty water condition, and by adding 2 or 3 lb. of sodium sulphite to a boiler just prior to taking it off has resulted in water free from rust after standing banked or cold for a number of days.

Can Probably Be Held Indefinitely

In view of the apparent success we are considering introducing sodium sulphite to the high pressure boilers in the generating stations where small quantities of dissolved oxygen are known to be present and also to boilers that are going to be idle for a few weeks. When a boiler has been off for cleaning and inspection, it will be filled with deaerated water and sufficient caustic soda added to raise the pH value to at least 11.0. Sodium sulphate will also be added for the purpose of establishing proper A.S.M.E. ratio. In addition sodium sulphite will be added and the boiler completely filled (including superheater and economizer). We believe that this will afford protection for the metal. The boiler can probably stand indefinitely under these conditions and when required for service it will only be necessary to drop the water to the steaming level. It is recognized that such a procedure would not be possible if freezing temperatures existed in the boiler room.

In connection with the use of sodium sulphite we have heard an unconfirmed rumor that at the higher temperatures corresponding to the higher steam pressures, sodium sulphite may decompose and liberate sulphur dioxide. If this is true the steam would be very corrosive. We have also learned of sodium sulphite being used at high temperatures without any injurious effect.

It may be that experience with the use of sodium sulphite is limited and that some further knowledge of the properties of this salt at higher steam pressures and temperature is necessary before using this material in high pressure boilers for the removal of small quantities of oxygen. However, should the salt be found stable under the above conditions it would furnish an ideal means of overcoming some of the difficulties encountered in the laying up of boilers for indefinite periods.

Results of the experiment with low pressure boilers appear to justify the use of sodium sulphite at steam pressures up to 125 lb. ga. If it should later be established that sodium sulphite decomposes at high pressures and temperatures, its use may still be justified for laying up boilers by draining the boilers and refilling before putting them in service.

The pH Indicator *in the Boiler Room*

Easily and Rapidly Applied Tests May Be Used to Guide Operator in Maintaining Water Noncorrosive

By WARREN VIESSMAN*

AS ORDINARILY used in the boiler room, the pH indicator is a comparative color test, easily made by the average engineer, to determine the pH value, or hydrogen ion concentration of the water. pH is the logarithm of the reciprocal of the hydrogen ion concentration expressed as mols per liter.

The colorimetric method depends upon the action of certain dyes or indicators in changing colors in solutions of certain pH values. To cover the full range of pH values a number of different indicators are used. In operation it is only necessary to take a small sample of the liquid to be tested, add to it a measured quantity of the indicator and compare the resultant color with fixed standards corresponding to known pH values.

A potentiometer method which measures the voltage developed by the hydrogen ions is also available.

These methods have been used in the chemical industries for some time. Their use in the power plant, while somewhat new, is rapidly becoming universal.

Hydrogen ion concentration is a measure of the alkalinity or acidity. It differs from the ordinary alkalinity or acidity tests in that it is not only more sensitive but is highly accurate as an indicator of the degree of active acidity or alkalinity, as contrasted with total acidity or alkalinity as determined by titration methods. For an explanation of the pH value we must turn to the causes of acidity or alkalinity. Pure water is expressed by the formula H_2O. This may be written $H^+ - OH^-$. According to the theory of electrolytic dissociation, when water is ionized it contains hydrogen ions, that is atoms or groups of atoms that will carry an electric charge, expressed as H and hydroxil ions OH. When there is the same number of H ions and OH ions, the solution is neutral. When there is a greater number of H ions the solution is acid, and conversely when there are OH ions in excess of H ions the solution is alkaline. The difference between strong and weak acid is due to the extent to which they are ionized.

Neutral Solution Has pH Value of 7.0

It is not necessary to have a knowledge of chemistry to interpret hydrogen ion values, but only to remember that a neutral aqueous solution has a pH value of 7.0, that an acid solution has a pH value less than 7.0, and that an alkaline solution has a pH value greater than 7.0. Also, since the pH values are logarithmic functions, a solution having a pH of 5.0 is ten times as acid as one with a pH value of 6.0.

The pH value of raw water supplies can be considered as due to the carbonate hardness, which is made up of an alkali and free CO_2. The pH value depends on the amount of each constituent present. There is a certain definite relation between the carbonate hardness and the free CO_2 which determines the pH value and which can be expressed according to the following approximate formula.

$$pH = \text{Log} \frac{\text{Methyl Orange Alkalinity as } CaCO_3 \text{ in p.p.m.} \times 2}{CO_2 \text{ in p.p.m.}} \times 10^6$$

Results of this relationship are plotted in Fig. 1. A water low in mineral solids or carbonate hardness is likely to be more corrosive than one of relatively higher carbonate hardness.

Corrosion difficulties are encountered in a large number of plants all over the United States. Corrosion is chiefly due to oxygen and carbon dioxide in the water. The pH indicator can be used to control the deaeration or chemical treatment of raw water to reduce this tendency.

Let us assume a well water of the following analysis,—

	p.p.m.	gr. per gal.
Temporary hardness (as $CaCO_3$)	4.0	0.2
Permanent or sulphate hardness (as $CaCO_3$)	11.6	0.7
Total hardness (as $CaCO_3$)	15.6	0.9
Free Carbon Dioxide	50.0	
Iron total as Fe	0.16	
Iron dissolved as Fe	0.08	
pH	4.7	
Turbidity	less than 1	
Color	7	
Odor	none	
Chlorides (as Cl)	3.0	
Free Chlorine	0.0	
Methyl Orange Alkalinity ($CaCO_3$)	4.0	
Phenol Alkalinity ($CaCO_3$)	0.0	
Reaction to Methyl Orange	alkaline	
Reaction to Phenolphthalein	acid	
Suspended matter	fine	

(17.1 parts per million equals 1 grain per gallon)

*Engineer, Baltimore Pure Rye Distilling Co.

Assume that it is desired to fill a boiler with this water, and hold the same in reserve for an indefinite period, and that a pH of 9 is desired to prevent corrosion. Let 6500 gal. represent the boiler water capacity. Figure 2 shows the relation between pH value and grains per gallon of caustic soda and soda ash. These curves can be obtained by titration methods, for the particular water, but sufficient accuracy can be obtained in most cases by using the relationship as shown.

Soda ash, or sodium carbonate, Na_2CO_3, is the less expensive material per pound, but since it is desired to eliminate free CO_2 from the water, caustic soda, or sodium hydroxide, NaOH, is selected.

$$2NaOH + CO_2 = Na_2CO_3 + H_2O$$

From Fig. 2, it is seen that 1.1 grains of NaOH is required per gallon of water to raise the pH from 4.7 to 9.0. Then since there are 7000 grains in a pound, the NaOH required by the boiler water is,

$$\frac{1.1 \text{ gr. per gal.} \times 6500 \text{ gal.}}{7000 \text{ gr. per lb.}} = 1.02 \text{ lb.}$$

Adding this amount of caustic soda will therefore be sufficient. A sampling connection on the boiler would permit a periodic check by means of the pH indicator.

Determination of Free CO_2

Another use for the indicator would be in the case of treated water, where a sample of the boiler feed could be readily checked for pH, and from the known methyl orange alkalinity, and the observed pH value, the free CO_2 can be easily determined from Fig. 1. For example let us suppose that the above well water has been partially deaerated and some CO_2 driven off, in an open heater, and that the partially deaerated warm water is being used for boiler feed. It is desired to determine the free CO_2 in the boiler feed. A pH test made at the feed pump reveals that the pH value is now 6.0 instead of 4.7, which was the value as the water comes from the well. From Fig. 1, for a methyl orange alkalinity of 4.0 and a pH value of 6.0 we find that the CO_2 has been reduced from the original value of 50 p.p.m. to 7.8 p.p.m.

The pH value is an index of the tendency toward corrosion caused by carbonic acid in the presence of oxygen. The temperature also plays a part in the actual corrosion, as it has been demonstrated that active corrosion will vary directly with the temperature for a given CO_2 and O condition.

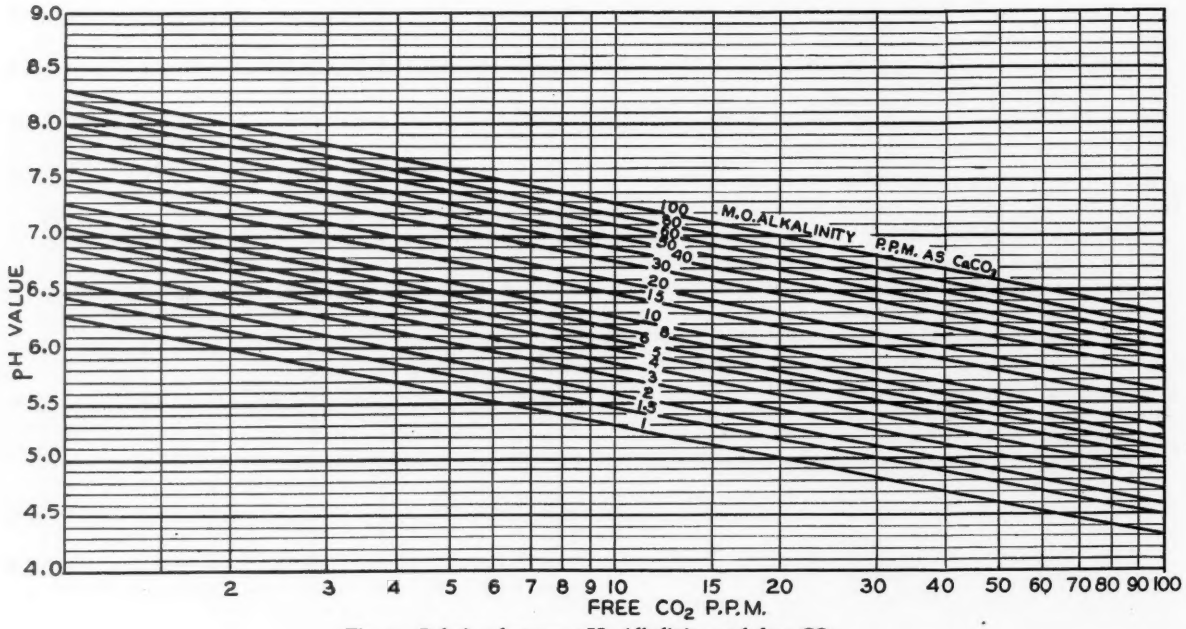


Fig. 1. Relation between pH, Alkalinity and free CO_2

The pH indicator is thus highly valuable in all industrial plants having free CO_2 in the boiler feedwater, or where the water contains carbonates which might be broken down in the boiler, due to heat, to form CO_2, which would be carried over into the piping and equipment. It is entirely possible to have no CO_2 in the boiler feed, but due to carbonates in the boiler, to find CO_2 in the condensate return, as indicated by the pH test.

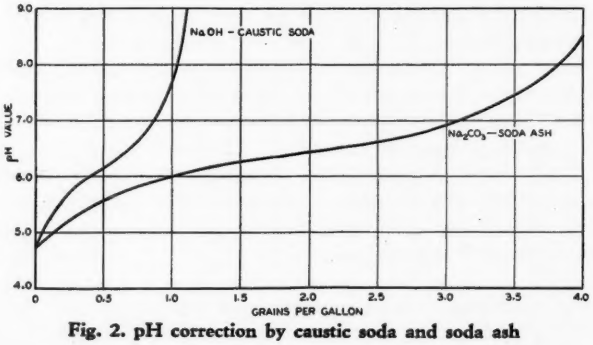


Fig. 2. pH correction by caustic soda and soda ash

The pH value of water in a boiler may be higher

than at any other part of the system, due to concentration of chemicals and decomposition of sodium carbonate to caustic soda, due to high temperatures. According to C. E. Joos, the decomposition of sodium carbonate within steam boilers will be from 70 to 90 per cent depending on pressure. From the decomposition of soda ash there is formed caustic soda and carbon dioxide. The carbon dioxide leaves the boiler with steam, while the caustic soda concentrates and is removed by the blowdown. Since the decomposition has no effect on the total alkalinity, but simply converts carbonate to caustic, the pH value is increased without any increase in the total alkalinity. It is for this reason that the pH value of concentrated boiler water is frequently around 11 or 12.

On the other hand the pH value of condensed steam in the return lines might be around 5, indicating highly active corrosion.

It is not the purpose of this article to discuss feedwater treatment, but merely to point out that wherever CO_2 exists in feedwater or steam, whether by introduction as free CO_2, in the raw water, or by decomposition of mineral substances, a pH indicator is a valuable check on conditions which may cause corrosion.

When I Buy My Power Equipment

By MARK BELL

WHEN, as a manufacturer, I decide to invest in additional equipment, either to replace or enlarge, I am going to get the best I can for my money in every way.

My best bet will be to consult my own engineers. Year by year, 24 hr. a day, they are with my plant. They are interested in its efficient and economical operation; they are in touch with other practical operating men through the medium of excellent engineering magazines or personal contacts; they have nothing to gain except release from worry and, if I am a smart man, I am going to abide by their judgment and order what they recommend.

In several plants I have visited there have been one or more suggestion boxes hung up but in the great majority no inducement is given to the employees to improve or make constructive suggestions.

I have never been able to find any valid reason for this lack of foresight. It is, at most, a very simple job for the manager to go through these boxes once a week. Of one thing I am certain, if more attention were given to the advice and suggestions of men in the plant and less to outside influence, costs would be kept down, the product could be manufactured more cheaply and, as a natural corollary, sales would increase.

Some of the instances I propose to give may appear trivial and would be in some cases. Many plants here, however, have quite a few subsidiary plants and, if the instance is multiplied by that number, the sum gets worth consideration.

We will now take a specific instance. A company with many plants operates at each a long battery of chillers. A thick liquid is pumped through these and, coming into contact with internal brine pipes, is reduced in temperature to around 28 deg. F. The liquid goes to the chillers at about 300 lb. per sq. in. pressure and the temperature control is effected by throttling each chiller at the discharge valve. Naturally, at this temperature and the fact that it is thick originally, it is almost a solid when it passes through the discharge valve. If the discharge valve is opened ever so slightly the pressure will ensure a flow and prevent the chiller from freezing up.

There is a lot to be said for gate valves and globe valves. Both have their uses in their own particular place but, when one needs a fine adjustment the best type to use is a globe. In a gate valve there are two threads to give lost motion; there is a small lifting of the valve before an orifice appears. With a globe valve the smallest opening motion acts positively and gives a small orifice. Would it not seem more practical to fit globe valves in this instance? Yet, gate valves were installed and much lost time resulted. The man operating the battery of chillers would go from one to the other. This one would show a degree or so too high; he would cut down slightly on the valve. If he closed a shade too much he would close the orifice and the next time he came around he would find it was frozen up. Then, he would have to open up wide on his valve and watch very closely until the pressure forced its way through and, however alert he was, he would get a big slug of hot liquid through and have to begin the weary job of adjusting again. Even with the greatest of care, using gate valves, the man operating a batch of 18 chillers would have one or more frozen up with consequent loss of production or have one bursting through with a slug of hot liquid to diminish efficiency.

With globe valves this could not have happened. To cut down, the man would have closed down, noted the amount, opened up slightly less and known, positively, that he had an orifice and freezing up could not occur.

I was never able to see why this large company could not see daylight in this matter but, operating several hundred of these units, one can readily see that it would have paid them. I hope to give further instances another time.

BY SELLING fuel users on the idea that a lot of money can be saved by eliminating smoke, William G. Christy, County Smoke Abatement Engineer for Hudson Co., N. J., reports that smoke violations have been reduced 94 per cent in 4 yr. For 1934, despite a severe winter, the fuel saving amounted to $223,000, and for the 4 yr. to $754,000 due to efficient burning of fuel. Besides, 2312 permits were issued during the year for new smokeless fuel burning equipment, for which the fees were $8035, or 28½ per cent of the Smoke Department's budget of $28,000. The savings represent 700 per cent return on this budget.

Double Acting Diesels
for Peak Load Service

New Swiss Plant with Three 7400 Hp. Sulzer Units is the Largest in Europe

AS A STANDBY and peak load plant for the Kubel hydroelectric station, the St. Gallen-Appenzell Power Works installed three 7400 br. hp. Sulzer Diesel engines, each direct connected to a 5000 kw. Oerlikon generator. The electric switch gear for the Diesel units is located alongside the control equipment for six hydraulic units in an adjoining building and orders for starting the Diesel units are transmitted from there by luminous signals. This is the latest Swiss Diesel engine plant to be built and is the largest in Europe.

Engines are of the 8 cylinder, double acting, 2 cycle, solid injection type, 600 by 1000 mm. (about 23.6 by 39.4 in.) and, at the normal speed of 187 r.p.m. have a continuous rating of 7400 and 15 min. over load rating of 8500 br. hp. although on test they carried, for short periods, loads of 9250 hp. or 25 per cent over load. Scavenging air is supplied by reciprocating compressors direct connected to the crank shaft.

Due to the large number and regularity of power strokes, the double acting, 2 cycle construction gives a smooth torque, although the necessary stuffing box for the piston rod somewhat complicates the design. This construction is shown by Fig. 1. The crank case is oil tight and oil is kept from traveling up the piston rod by means of an oil scraping device made up of cast iron segments as shown. Above this oil scraper is the actual stuffing box which is formed from part of the lower cylinder head. This stuffing box is packed to take the ignition pressure in the cylinder, the packing consists of segments pressed lightly against the piston rod as shown in detail by Fig. 2.

Piston rods are bored to form passages for the cooling water to and from the piston. This arrangement is also effective in cooling the piston rod. The pistons themselves, as shown by Fig. 3, are made in four parts, an upper and lower head take the gas pressures, each fitted with five piston rings. These top and bottom pieces are supported directly against a strong flange on the piston rod and secured by a circle of bolts. A guide sleeve of cast iron supports the piston at the side against the cylinder walls and the whole is enclosed by a cover.

Stainless steel tubes are used for conducting of cooling water to and from the pistons, these pass through the crank case and have oil scrapers. They may be inspected while the engine is running. Stuffing boxes prevent leakage from the water space. This cooling system requires water at a pressure of from 25 to 30 lb. per sq. in.

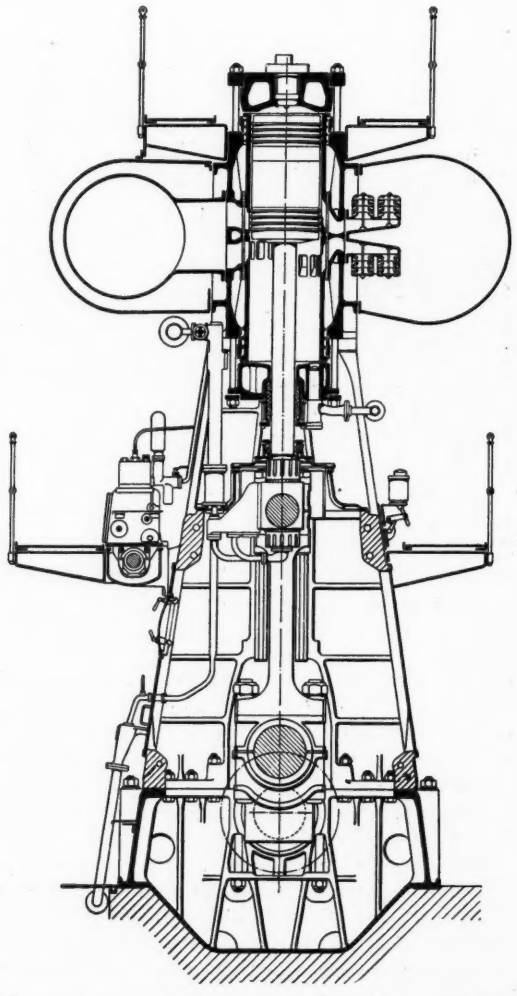
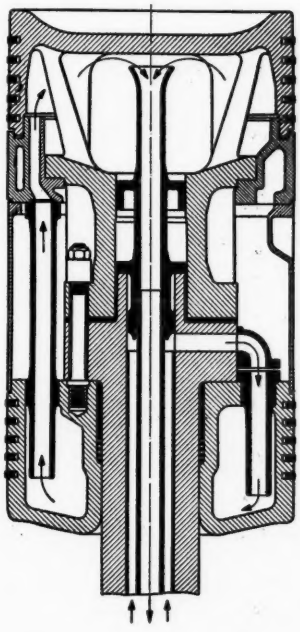


Fig. 1. Cross section through one of the three 7400 hp. Sulzer engines in the Kubel Station. The generator rotor has sufficient WR^2 effect to act as the flywheel

Oil required for cylinder lubrication is introduced at 8 points and as shown by the cross section the cylinder heads rest directly on the liners. Each cylinder has two rows of scavenging ports with scavenging valves in front of them. The ports in the upper row are directed upwards and those in the lower row downward. Exhaust ports are also in two rows and arranged

opposite the inlet ports. Flow of the scavenging air for the lower end of the cylinder as determined by experiments is shown in Fig. 4. After leaving the cylinder it unites into one stream which passes to the right and left of the piston rod, crosses over to the exhaust side and rises up the cylinder again. When turning at the bottom, the air scavenges the combustion pockets effectively.

Fuel pumps shown by Fig. 5 work at a pressure of from 5700 to 8700 lb. per sq. in., according to the load on the engine. For each injection spot there is one simple plunger, ground into a cast bushing. The stroke of the plunger remains constant at all loads and the delivery begins at the same moment for every load, but, by opening an overflow valve, the cut-off is timed to occur earlier or later according to the load



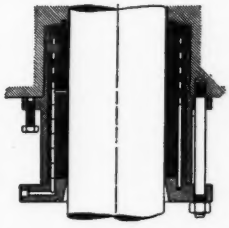


Fig. 2 (Above). Stuffing box at the lower end of the cylinders

Fig. 3 (Left). Section showing the piston water cooling system

on the engine. These overflow valves are opened at the same point for all cylinders by means of a load regulator. In compliance with specifications each engine is capable of developing 6400 br. hp. continuously with one cylinder out of operation.

Lubricating oil for the engine is kept in the bed plate and in the lubricating oil filter. Before starting the engine all lubricating oil piping and bearings, as well as the servomotor for the hydraulic governor, are put under oil pressure by means of an electrically driven gear wheel pump. For standby service when electric current is not available an air operated pump is installed.

At full load the quantity of heat to be carried away amounts to about 14,000,000 B.t.u. per hr. for each engine, or about 27 per cent of the heat of the fuel. Cooling water is taken from the tail race of the power station and a cooling water pump is provided for each engine. In case of failure of the pumps, cooling water is supplied automatically from the delivery pipes to the hydraulic turbines.

Due to the importance of the station as standby, particular attention was paid to the matter of starting. In the official trials it was found possible to have the first unit running and ready to parallel with the electric system in one and one-half minutes from the time the operator had been called and entered the station. Within 5 min. the entire plant can be brought up to full load.

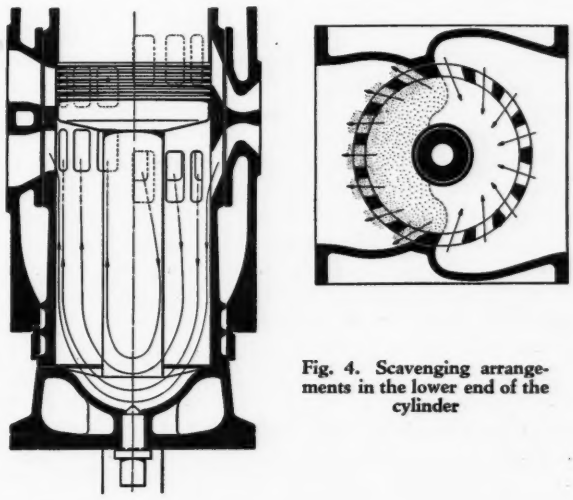


Fig. 4. Scavenging arrangements in the lower end of the cylinder

For starting the engines three preparatory operations are required: 1. Putting the cooling water circulation into operation; 2. Starting the lubricating oil pumps; 3. Opening the fuel pipe and air starting bottles. To start the cooling water circulation the operator has to go down to the pump room but in the case of an emergency the system can be put in operation by pressing a button and opening the emergency connection with the turbine delivery pipe. Each engine has three 35 cu. ft. air starting bottles, filled to a normal pressure of 40 atmospheres (about 580 lb.) by means of electrically driven compressors.

After the preparatory operation it is only neces-

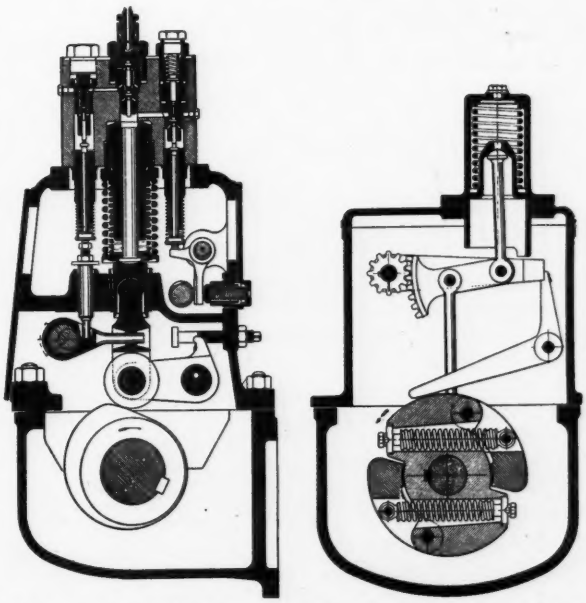


Fig. 5. Details of the fuel pump (left) and over speed trip (right)

sary to turn the handwheel on the engine. The following operations are then carried out positively and automatically:

Opening the control valves for the starting air, compressed air then flows through the piping to pre-starting valves in separate cylinders and operate the main starting valve pneumatically. Compressed air is then admitted at the proper time to the lower cylinder ends, starting the engine rotating. Immediately after this the delivery of fuel to the upper end of the cylinder commences. As soon as the engine is firing in the upper ends, the starting air is shut off from the lower ends and delivery of fuel is started there.

Arrangement for stopping the fuel pumps is as follows: A shaft, fitted with cams, passes along the engine through all the fuel pumps and is operated by the control hand-wheel. By means of the cams the suction valves of the pump are freed one after the other. In stopping the engine it is sufficient to turn the service handwheel to the stop position. This shuts off the delivery of fuel and the engine comes to rest.

Above the service handwheel is an instrument board showing the pressure of the piston cooling water, cylinder cooling water, lubricating oil, scavenging air and starting air. On the wall of the engine room is a remote thermometer for measuring the exhaust temperatures while a thermometer showing the cooling water temperatures is installed on each cylinder. An easily accessible lubricating oil branch pipe is provided for each of the ten main bearings so that the quantity and temperatures of the oil at each bearing may be controlled.

On the tests fuel consumption in pounds per kilowatt hr. ranged from 0.592 at half load to 0.538 at full load. At the guaranteed over-load capacity of 15 per cent the fuel consumption was 0.546 lb. per kw. hr. but during the trials the over-load was increased up to 25 per cent for a short period and fuel consumption increased to about 0.56 lb. per kw. hr. On one brake horsepower basis these fuel consumptions are 0.425, 0.382, 0.389 and 0.4 lb. per br. hp. respectively. The two sets of figures do not bear an exactly constant relationship, of course, because the generator efficiency varying slightly with the load is involved.

Accident Lessons

A POWER AND LIGHT COMPANY LINEMAN was pulling up slack in secondary wires. A home-made "J" hook was fastened to his safety belt near the "D" ring. This hook was used for carrying washers or other equipment. When the lineman placed his safety strap around the pole, he snapped it into the "J" hook instead of the "D" ring. When he leaned back against the belt, the strap slipped from the "J" hook and he fell 28 ft. Fortunately, his injuries were not fatal.

This was one of the accidents called to the attention of members of the Public Utilities Section of the National Safety Council during 1934, with the hope that suggestions might be made and remedies applied. In this particular case, it was pointed out the lineman was directly responsible, but that the foreman should have made a closer inspection of the tools. To prevent a recurrence of this accident, the lineman's company made a rule forbidding the attachment of any apparatus to a life belt within four inches of the "D" ring.

Shortly after this report was submitted to the Section, this comment came from Canada:

"If the lineman used a leather plier holster, and only a leather tool keeper on his belt, this type of accident could be prevented. We had two similar accidents to the one described. We now supply all belts, and do not allow the linemen to make any additions to the belts, as they are not their property."

An arc circuit had blown out during a heavy wind and rain storm. A suburban district manager found that the arc circuit had broken where it had worn in a tree insulator. He made the splice on the ground and climbed the 30-ft. pole to pull out the slack and tie in the conductor on the insulator.

His left hand came in contact with the conductor, causing current to flow through his body from his little finger, out through a point near the groin to the pole and to the ground. The pole was creosoted and wet. He was not wearing rubber gloves. One rubber glove was wrapped around the conductor and the other was on the ground. His hooks had cut out and his body was hanging by his safety belt, with no part of his body in contact with the conductor.

It was later found that a 2,300-v. primary was crossed with the street lighting circuit about six blocks from the scene of the accident and on the other end of the circuit from the joint he had made on the ground. The pole was a 30-ft. creosoted pine and had only one two-pin cross arm, with one No. 8 arc circuit on it.

There was considerable confusion in reporting the accident and the workman's body remained on the pole approximately 45 min. The rescue crew worked on the body for three and a half hours until a physician pronounced the man dead.

"Men working on series circuits shall consider the line as hot when the switch is open as well as closed," was the rule of this company. "This affords the workmen protection from accidental contacts between the primary and series wires."

The danger in defective or improperly made tools is reflected in this accident report.

The injured man was holding a chisel bar with tongs while another employee used a sledge hammer in the process of chipping out a concrete foundation. A sliver of steel flew from the chisel bar and struck the injured man on the right forearm, cutting a deep wound approximately two inches long. The doctor had to make another incision to remove this particle of steel. There was a loss of 15 days. The chisel, it was found, had been made by a local shop from a piece of automobile axle. The head was not properly annealed.

A groundman was melting pitch in a gallon bucket over a furnace. As the tar became hot, it blew out of the can. The groundman, observing this, walked over to the furnace to investigate when the tar blew up a second time, this time throwing hot tar into his face and causing severe burns. Although he said that he saw the tar when it first blew into the air, he admitted that he went close to the tar to investigate, instead of using a stick or some other implement with which to remove the pot.

Test Engines *for Diesel Fuel*

Progress in the Art of Diesel Fuel Testing as Told to the A.S.M.E. by T. B. Rendel, Engineer in Charge of Automotive Research Laboratory, Shell Petroleum Corp., St. Louis, Mo.

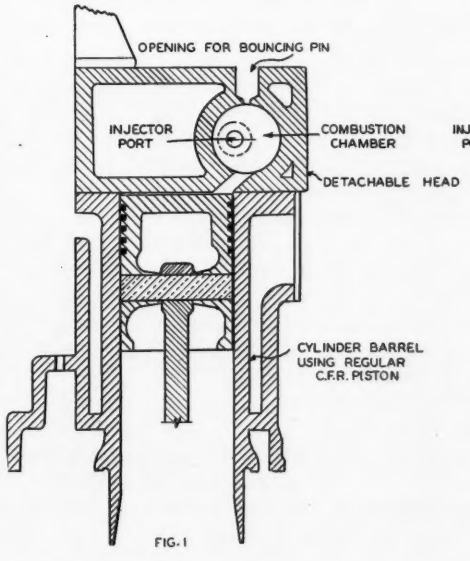
NECESSITY, which was the maternal parent of the modern Diesel engine, was the need for a prime mover which could efficiently utilize the wide range of oils lying between gasoline and the heavy residual oils, such as road oil and asphalt. Most people are familiar with the mechanism of combustion, which, in a solid injection engine of this type, may be considered to take place in three stages starting from the commencement of injection; first, a delay period, during which no appreciable combustion takes place and the fuel is heated up to its ignition point; second, the rapid burning of the fuel which has been injected during the delay period; third, the instantaneous ignition of the remainder of the fuel as it enters the flaming gases from the fuel injection valve.

Now, for any given timing of injection of the fuel, the rate of rise of pressure and the maximum pressure reached during the second stage of combustion, depend primarily upon the duration of the delay period, that is, the time involved in the first stage of combustion. The longer the delay period, the higher will be the rate of rise in pressure and the greater the maximum pressure reached since a greater amount of fuel will have been injected into the cylinder before combustion starts and the rate of burning comes under the direct control of the fuel injection equipment. Minimization of the duration of this delay period, therefore, is desirable if we are to have proper control of the fuel combustion.

The duration of this delay period is controlled, to a large extent, by the engine design, and can be reduced by providing suitably located hot spots in the combustion chamber to serve as ignition points and by properly controlled turbulence. However, the ignition quality of the fuel also plays some part in determining the duration of this delay period and it is for this reason, therefore, that the engineers and fuel technologists must co-operate in a study of the relative significance of fuel ignition quality and engine design, if the development of the Diesel engine is to be carried forward to a point where it can successfully compete with the development of gasoline engines and still use the wide range of heavy oils available between gasoline and heavy residual oils.

Measurement of Ignition Quality

Although it is well known that the ignition quality of a Diesel fuel is dependent generally upon its chemi-



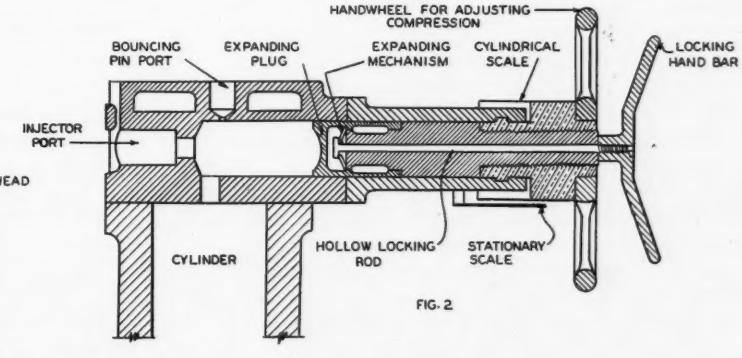


Fig. 1 (Left). Section of the new Diesel cylinder for the modified C.F.R. engine

Fig. 2 (Above). Section of the head showing the method of varying the combustion chamber volume

cal composition, as yet no standardized method of measuring it has been developed, which will give results which are valid in terms of actual engine practice and can be generally accepted as a reproducible routine method.

Two of the methods which have been proposed and which seem to be the most promising, involve the use of actual engines rather than tests in some form of "bomb." The method best known in this country has been proposed by Pope and Murdock (S.A.E. Journal March, 1932) in which use is made of a modified C.F.R. engine to determine the critical compression ratio at which the fuel will fire within three seconds after being injected into the cylinder when the engine is externally driven at 600 r.p.m., the intake air temperature being maintained at 100 deg. F. and the jacket temperature at 212 deg. F.

The other promising method was that proposed by Boerlage and Broeze (S.A.E. Journal, July, 1932). This method involves the measurement of the actual ignition delay by means of a pressure-time indicator in a large slow speed solid injection engine at a compression pressure of 450 lb. per sq. in. The engine used is run at one quarter load with a jacket temperature of 165 deg. F. The delay is compared with the delay obtained on mixtures of cetene and alphamethylnaphthalene and the percentage of cetene which gives the same delay as the fuel under test is called the cetene number. The cetene number is therefore analogous to the octane number of gasoline. Both methods have some disadvantages, though it would seem as if the method proposed by Boerlage and Broeze relates more nearly to actual conditions than that proposed by Pope and Murdock. The C.F.R. engine, however, has the advantage in that it is already widely adopted for gasoline testing.

New Type C.F.R. Diesel Cylinder

Early in 1932 experiments were started in the author's laboratory on a converted C.F.R. engine which showed that critical compression ratios could be determined with fair reproducibility provided great care was taken to see that the engine was clean. The engine, however, soon got out of condition and recent cooperative experiments have shown that agreements between two different engines are not good.

Early in 1933 it was decided to redesign the entire cylinder and cylinder head of the C.F.R. engine in the light of the best available knowledge of combustion chamber design in order to obtain steadier operation. This work was carried out at the laboratory of the Royal Dutch Shell Group at Delft, Holland, in cooperation with the Waukesha Motor Co. Figures 1 and 2 are sectional drawings of the new head and cylinder, showing the general design features and the mechanism for varying the volume of the combustion space.

This cylinder has now been in continuous use in the author's laboratory for over a year with satisfactory results. It is possible to use both the critical compression ratio method of rating fuels described by Pope and Murdock and also, in conjunction with a modified type of bouncing pin, the delay method suggested by Boerlage and Broeze, and to obtain measurements of the ignition quality of a Diesel fuel with reasonable accuracy and with a minimum amount of engine maintenance.

Regarding the critical compression ratio method, reproductibility has been determined by running five samples ten times each over a period of about three weeks. Calibration curves were also determined to obtain the critical compression ratio of various mixtures of cetene and alphamethylnaphthalene, the curves being checked every day. From these curves the critical compression ratios of the fuels were converted into cetene numbers. The grand average deviation of these 50 check tests was +1.9 cetene numbers, the maximum deviation being 7. In a similar test made on the old type cylinder the grand average deviation for 51 check tests was about +2.3 cetene numbers, with a maximum deviation of 10.4. The new cylinder seems to show also a greater sensitivity to ignition quality.

When operating according to the delay method, the method of test is similar to and employs the main advantages of the octane number antiknock test for gasoline. Briefly, the new test method utilizes a bouncing pin that has been rebuilt to break instead of make

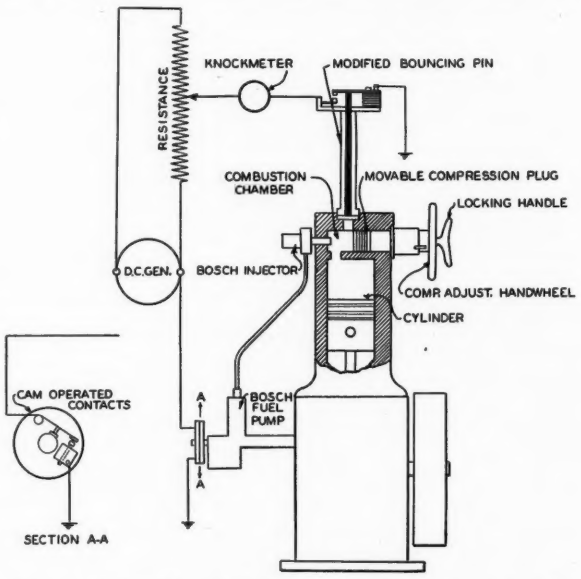


Fig. 3. Modified bouncing pin circuit for delay measurements

an electrical circuit when the pin is "bounced" upward by the shock of combustion. It is thus used to stop a current that is started by a cam on the end of the fuel pump shaft, timed to make contact at the time the fuel is injected. Just exactly how close the time at which the cam makes contact corresponds to the actual time of injection has not yet been accurately determined. The difference between different fuels, however, is apparently small and relatively unimportant. The total current that flows from the time the fuel is injected until the time combustion begins, i. e., the time when the pin is "bounced," is a measure of the delay period.

By allowing this current to flow through a regular knockmeter similar to that used on the gasoline knock testing engine it is possible to find a mixture of reference fuels with the same knockmeter reading, and hence delay period, as the fuel under test. By using

(Continued on page 245)

Constant Pressure Engine Control

European Artificial Silk Factory Regulates Engine Load to Maintain Constant Exhaust Pressure

INDUSTRIAL REQUIREMENTS for steam regulation for maximum efficiency are sometimes complex and a recent installation in a European artificial silk factory* is of unusual interest. This control, used with a 350-kw. Sulzer back pressure steam engine, is shown in diagrammatic form in the illustration. Steam from a 500 lb. ga. Sulzer steam generator reaches the engine through a separator, E, at about 450 lb. ga., 660 deg. F. It is expanded in the engine down to about 8.5 lb. ga. and exhausted to the heating system. Live steam from the boiler can also be fed to the heating system through the by-pass and the automatically operated reducing valve, S.

Heating system pressure is maintained constant by means of the regulator N_2 which controls the speed governor H to the control valve R. The load in the engine is thus regulated in accordance with the demands of the heating system. The second control valve operated from the same regulator N_2 actuates to the pipe T a remote speed control on an older Sulzer steam engine working on 170 lb. ga. steam pressure.

According to the original arrangement, the same regulator controlled the live steam makeup valve S in such a way that if the pressure in the heating system fell, the regulator N first increased the load on the new engine B up to its maximum output, then put additional load on the older 170 lb. engine and finally opened the live steam make-up valve S.

In case the capacity of the high pressure boiler was not sufficient to supply the heating system, another automatic reducing valve, not shown in the illustration, was provided so that steam might be bled to the heating system from the 170 lb. steam system. In this way the heating system pressure was to be maintained constant under all conditions, with the steam engines operating at full load before live steam passed through the reducing valve.

If pressure in the heating system increased, regulation took place in the opposite manner. First of all the pressure reducing valve from the 170 lb. system was closed, then the valve S, after which the load is reduced first on the old engine and finally on the new engine B.

Experience during the first months of operation showed that in order to obtain steady boiler operation it is desirable to regulate the steam engine, not according to the pressure of the exhaust system, but, according to the boiler pressure, that is, maintain the boiler pressure constant at 500 lb. In order to accomplish this the second steam pressure regulator N_1 has been added, to regulate the speed governor H of the engine in accordance with the pressure in the steam header.

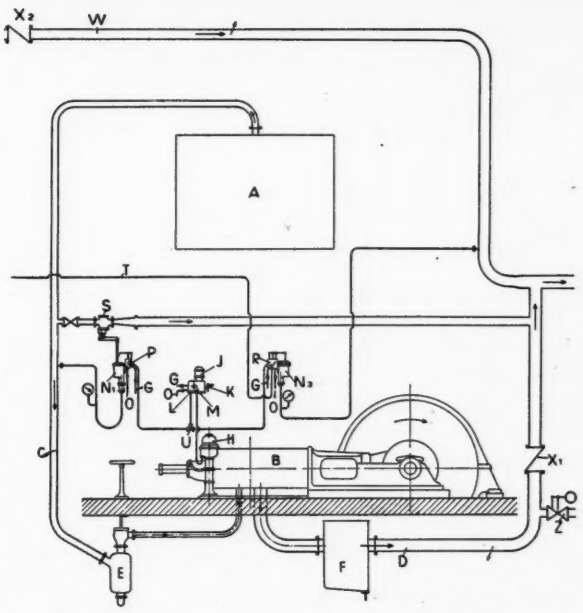


Diagram showing the method of regulation of a 350-kw. Sulzer steam engine generator set in an artificial silk factory

A, Steam boiler; B, new steam engine; C, 500 lb. steam main; D, exhaust pipe; E, steam trap; F, oil-separator G, oil pipes; H, Governor; J, motor for remote adjustment of speed (from the switchboard); K, handwheel for speed adjustment by hand; L, position lever for load regulation to constant admission steam pressure; M, position lever for regulating to constant speed; N_1, N_2, pressure regulators; O, oil outlets; P, pressure relays; R, double relays; S, hydraulically operated blow-off valve; T, pipe for regulating-oil of old engine; U, three-way cock; W, exhaust pipe of old engine; X_1, X_2, non-return valves; Z, safety valve.

At the same time this regulator N_1 operates the reducing valve S and the throttle valve comes into operation only when the engine is operated at full load at periods when all the steam generated by the boiler cannot be utilized. In this case the surplus steam flows through the valve S into the heating system. The regulator N_1 is in reality a boiler control since it automatically maintains constant boiler pressure.

Other features of interest are the hand operated speed adjustment K; the remote control speed adjustment G; the three-way cock U and the regulating control levers L and M. With the help of these levers the automatic regulators may be put out of action so that it is possible to adjust the speed as required by hand or from the switchboard by means of remote speed adjustment G. This is convenient when paralleling the generator set with the outside power supply.

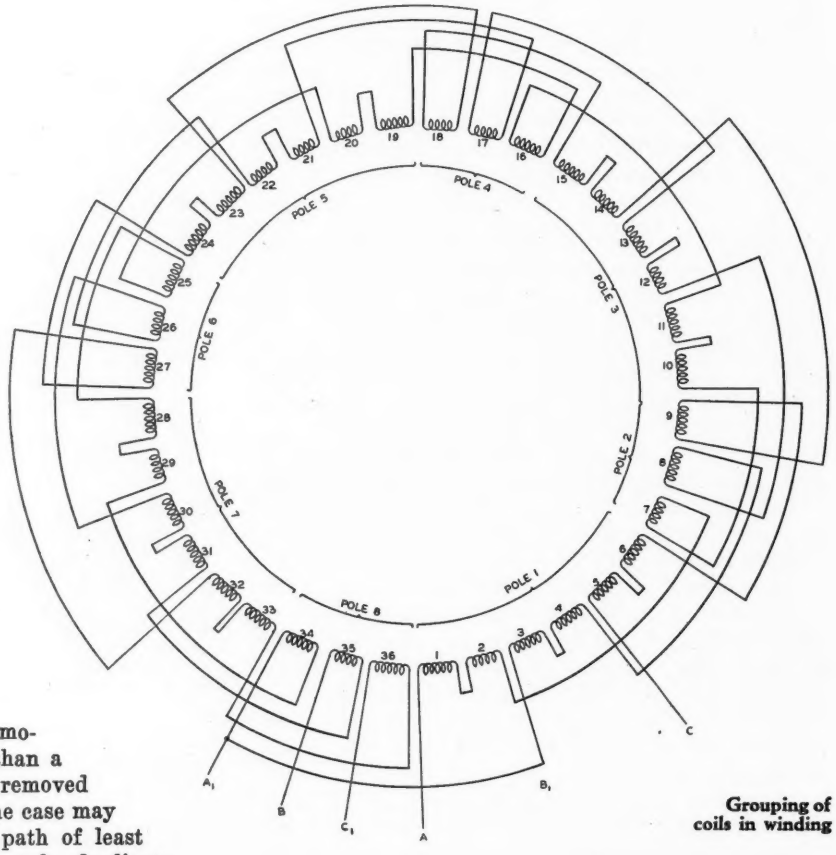
The steam pressure regulators N_1 and N_2 are of the standard Sulzer oil operated precision type in which oil under pressure is supplied to the whole system by a gear wheel oil pump on the new steam engine, or by an electrically driven auxiliary oil pump which allows the regulators to be kept in service when the steam engine is not running.

*See Increasing Boiler Pressure 300 per cent, Power Plant Engineering, May 1933, page 220, for details of changes in boiler room.

Calculations *for* Motor Rewinding

Accurate check on the winding data of a motor that persisted in burning out disclosed fact that original winding was not correct. Correct method for figuring winding data explained.

By
C. C. HERMANN



Grouping of coils in winding

REWINDING OF AN electric motor should consist of more than a mere duplication of the winding removed from the stator or armature as the case may be; yet many shops follow the path of least resistance in this regard and merely duplicate the winding whenever a motor comes into the shop with the winding in the slots. A danger lies in this procedure as indicated in a job which came to the writer's attention some time ago. In this case a small manufacturer not having a rewind service in his own organization sent a burned-out motor to a rewind shop. The motor was rewound and sent back, placed in service and in a comparatively short time burned out a second time. After this second failure it seemed advisable to the manufacturer to check up the motor. It would seem advantageous to set forth the entire procedure.

This motor was a three-fourths horse power, 440 v. 3 phase, 60 cycle, 900 r.p.m. synchronous speed, fully enclosed, fan cooled unit. The name plate rating was 55 deg. F. at full load speed of 840 r.p.m. for one hour.

The winding data taken from the motor after the first failure at rewinding was as follows, the initial data having been lost.

Number of slots, 36.
Number of coils, 36.
Turns of wire per coil, 60.
Size of wire, cotton covered enamel, 21 Ga.
Number of poles, 8.
Unformed length of coil, 6¼ in.
Total length of wire per phase, 780 ft.
Pole phase groups, 24.

Coils per group, each alternate pole, two coils per phase, all other poles one coil per phase. The grouping is shown in the accompanying diagram. It is observed from the diagram that the winding is symmetrical about a center line taken between any two poles on one side and two poles diametrically opposite. The diagram also shows that the motor is single circuit star connected.

Since there are 36 slots and 8 poles the coil pitch will be 36/8 plus 1 or 5 which is full pitch. It is to be pointed out here that the pitch should never be larger than full pitch and preferably smaller than full pitch or as it is called "short-pitch" for the reason that short-pitch tends to smooth out the wave of induced e.m.f. making it approach more closely to the sine form. This fact will be made more apparent later in considering the winding for this example.

It is necessary to make certain measurements of the stator core in order to determine the correct de-

tails of the winding. Such dimensions, in inches taken from the stator in question, are as follows:

Bore, 4.75.
Outside diameter of core, 7.8125.
Thickness of core, 2.5.
Slot depth, 1.03125.
Diameter to middle of slot, 5.78125.
Slot pitch = 5.78125 × 3.1416/36 = 0.5044.
Tooth width, 0.1875.
Slot width = 0.5044 — 0.1875 = 0.3169.
Iron depth below slot, 0.5.
Iron cross sectional area below slot = 1.25 sq. in.
Tooth cross sectional area = 0.1875 × 2.5 = 0.46875 sq. in.
Teeth per pole = 36/8 = 4.5.
Teeth per pole effective at one time = 4.5 × 0.636 = 2.86.
Area of effective teeth = 2.86 × 0.46875 = 1.342 sq. in.
Distribution factor = 0.955.
Chord factor = sine of ½ the angle in electrical degrees of the coil pitch = 0.98.
Volts per phase = 440/1.73 = 254 volts for three phase.
Flux per pole[1] = 45,000,000 × 254 ÷ 60 × 120 × 12 × 0.955 × 0.98 = 142,350 lines.
Density in tooth section = 141,350/1.342 = 105,330.
Density below slots through iron = 141,350/2 × 1.25 = 56,540 lines.

It is observed that the density through the tooth section is almost twice the density in the iron below the slots. It is noted from above that the flux per pole is 141,350 lines and that this flux must pass through the iron comprising the teeth in the pole area of which there are 4.5. Theoretically, however, the amount of iron involved is actually the area of 5 teeth. Therefore correcting our figures on this basis the density in the tooth section is 94,860 lines instead of 105,330. Compared with the density of the flux in the iron below the slots, 56,540 lines, this figure is high. It is to be noted that in the case of the iron below the teeth the flux flows both ways, that is, toward the poles on either side of the one considered; therefore the total flux is divided by 2 as indicated.

In general the flux should not exceed 100,000 lines per square inch. The figure, 94,860, is just within these limits; however, it is too close to the upper limit for many conditions of operation. Under very favorable conditions of operation such as low room temperature and intermittent load the motor would probably operate satisfactorily for a considerable length of time. As a fully inclosed motor the flux density should be lower. To reduce the flux density in the tooth section would involve an increase in the pitch of the coils which would have a bad effect on the characteristics of the motor. As indicated in an earlier paragraph the coil pitch should be shortened rather than lengthened to obtain improved wave form of the induced e.m.f. The better way to improve the condition in the tooth section is to increase the number of conductors per slot.

The slot size limits the number of conductors which can be laid therein; therefore, it becomes a matter of finding out just how many conductors can be placed in the slot. It is to be noted in winding the motor that the slot size is decreased by one thickness of fish paper 0.025 in. thick which is folded down against the iron so that this must be deducted from the depth of the slot and twice this amount from the width of the slot. We must also deduct four thickness of varnished cambric 0.010 in. thick or 0.040 in. from the depth of the slot and two thickness of varnished cambric from the width of the slot or 0.020 in. The total deductions are then 0.065 in. from the depth of the slot, remembering that the depth of the slot must be figured from the bottom surface of the offset which is produced to accommodate the holddown, and we deduct 0.090 in. from the width of the slot. Whereas the cross sectional area of the slot is, without the deductions, 0.3169 sq. in. and the deductions 0.0059 sq. in. we have left a net area of 0.311 sq. in. which we find is capable of receiving 144 conductors with ease. Before proceeding to wind the stator with 72 turn coils, however, it is well to check the results.

Conductors per phase = 45,000,000 × 254 ÷ 60 × 2 × 1.25 × 56,540 × 0.955 × 0.98 = 1440 conductors.

Number of phases, 3.
Total conductors = 3 × 1440 = 4320.
Number of slots, 36.
Conductors per slot = 4320/36 = 120.
Conductors per coil, 60.

This satisfies the condition for the iron section below the slot. Now for the iron in the teeth we substitute the cross sectional area of the teeth section effective under the pole namely 1.49 sq. in. for 2 times the cross sectional area below the teeth or 1.25 in the above formula thereby obtaining the number of conductors per phase as 2448. Going through the calculations as above the number of conductors per coil would then be 102. But we cannot place this number of conductors in the slots, namely 204; therefore we must revise the lines of flux upward in the teeth area. Let us take for trial a flux density of 75,000 which would be a great improvement over the initial density. The conductors per phase would then be 1728 and the number of turns per coil would be 72 or exactly 144 conductors per slot.

Since we have changed the number of conductors per slot we should also check the wire size. To do this we use the following method:

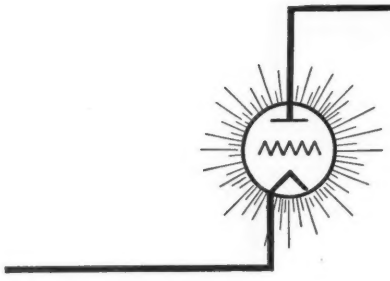
Full load current per phase lead = 0.75 × 746 ÷ 1.73 × 440 × 0.85 × 0.80 = 1.05 amp.

Copper required per ampere assumed at 750 cir. mil. Therefore the size of wire required would be 787 cir. mil. which is equivalent to number 21 ga. copper, cotton covered, enameled wire.

It is obvious that the original winding was not correct and this was further indicated by the fact that the rewound motor went into service and operated satisfactorily.

[1]Formula for flux per pole =
$$\frac{45{,}000{,}000 \times \text{volts per phase}}{\text{Cycles} \times \text{conductors per phase} \times K_1 \times K_2}$$
where K_1 and K_2 are the distribution and chord factors respectively.

The "Thyratron" Motor



By E. F. W. ALEXANDERSON and
A. H. MITTAG *both of the General Electric Co., Schenectady, N. Y.*

A New type of motor in which a scheme involving electronic tubes is used to perform a function similar to that of a commutator is described in this article which is an abstract of a paper by the authors presented before the winter meeting of the American Institute of Electrical Engineers in New York. The motor operates at variable speed and is supplied from a 3-phase power system. A 400 hp. motor of this type has been built for use on forced draft for service in one of the generating stations of the American Gas & Electric Co.

THE NEWLY DEVELOPED "thyratron" motor recently announced is analogous to a commutator motor because a group of "thyratron" tubes takes the place of the commutator and serves a similar purpose. It belongs to the group of developments which are based upon the discovery that the starting of the anode current in a gas arc rectifier could be controlled by a third electrode.[1] Tubes functioning on this principle are called "thyratrons."

In this application the thyratrons perform two distinct functions, one, grid controlled rectification and the other, commutation. Through the commutator function, a motor is made available which operates on an a.c. power supply but has smooth variable speed torque characteristics like a d.c. motor without any reference to synchronism with the a.c. system. The grid controlled rectifier function gives a motor which has continuous power from standstill to maximum speed. This power control has delicacy, quickness and accuracy superior to anything heretofore available. It may be operated manually or with remote control and lends itself well to automatic control for regulating speed and power for coördination with other machinery.[2]

The functioning of the thyratron motor can be best understood if it is looked upon as a species of d.c. motor. The elements of a d.c. motor are a power supply, a commutator, an armature and a field. In the new motor each of these elements can be identified. A set of thyratron tubes takes the place of the commutator, the armature is stationary and the field is rotating and the motor has a structural resemblance to the synchronous motor, but nevertheless the functioning of the armature and field can best be explained in terms of the d.c. motor.

The actual power supply used in the developmental arrangement as shown in Figs. 1 and 2 is 4000 v., 3 phase, 60 cycle. The thyratron tubes act as rectifiers with an output which appears in the form of direct current. The same set of tubes serves to guide the flow of direct current successively through the different sections of armature winding like brushes and segments of a d.c. commutator. This double functioning of the thyratron tubes may seem a little confusing at first but the matter can be cleared up by considering the arrangement shown in Fig. 3 in which one set of tubes is used for rectification and another set of tubes is used for commutation.

When the separate functions of rectification and commutation are understood it becomes easier to analyze the arrangement which is being used whereby each tube performs all the functions at the same time. As seen by the diagram in Fig. 1, the tubes are arranged in groups of three with reference to the power supply and each of these groups functions exactly like a single rectifier tube in Fig. 3. With reference to the motor, the tubes are also arranged in groups of three but in a different order and with reference to the motor the tube groups function like the commutator tubes in Fig. 3. While each tube has only one grid, it has two distinct grid controls one of which functions as a rectifier control and the other as a commutator control. To accomplish this it was necessary to find some method of combining these two grid controls in such

[1] See Tubes May Solve Your Problems, Power Plant Engineering, April 1934, p. 174 and May 1934, p. 230.

[2] As announced by Philip Sporn at the winter meeting of the AIEE where this paper was presented, the motor described was purchased by the American Gas & Electric Co. for use on forced draft fan service in one of their generating stations.

a way that the two functions would not conflict with each other. This has been accomplished by the grid control circuit in Fig. 2. The rectifier control is in the nature of a phase shifter and the commutation control in the nature of a distributor. When the phase shifter delivers a positive voltage and the distributor at the same time makes contact, a positive voltage is impressed on the grid making the tube conducting. Whenever the phase shifter delivers a positive voltage but

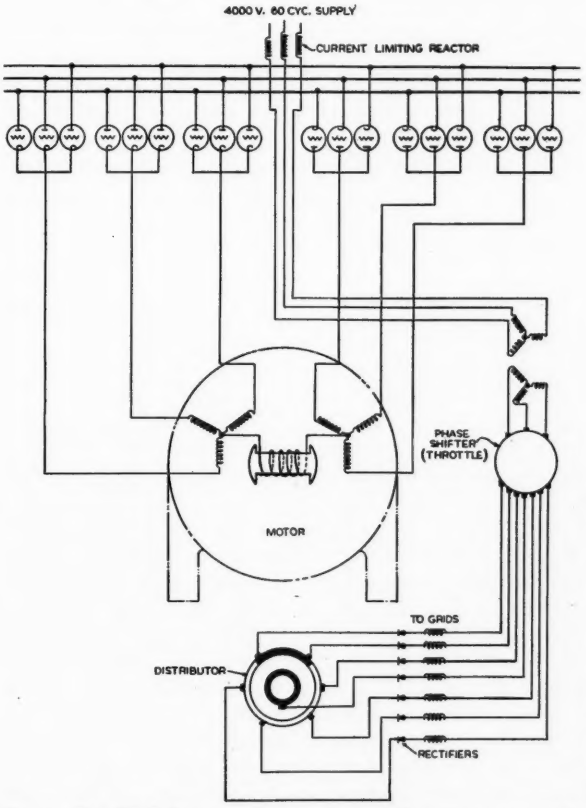


Fig. 1. Simplified diagram of connections of thyratron motor with grid circuit omitted

the distributor does not make contact, or whenever the distributor makes contact while the phase shifter delivers a negative voltage, the tube remains nonconducting.

Theory of Operation

When we state that a positive voltage makes the tube conducting and a negative voltage makes it nonconducting, we are only partially correct. It is true a positive voltage makes the tube conducting but a negative voltage merely prevents it from becoming conducting. A negative voltage does not interrupt a current which has already been established. This is a characteristic of the "thyratron" tube.

The transfer of current from one tube to another is called commutation in analogy of transfer of current from one commutator segment to another. In a d.c. motor with sparkless commutation the current is transferred from one segment to another by the electromotive forces in the windings acting between those two segments and not by the breaking of the contact be-

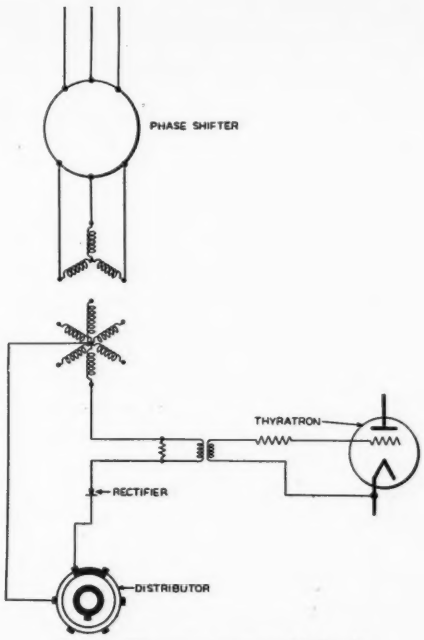


Fig. 2. Thyratron motor grid circuit

tween the brushes and the segments. This analogy between the d.c. motor and the thyratron motor is accurate because the transfer of current takes place as a result of electromotive force in the motor winding. If these electromotive forces are not adequate to complete the commutation, there is a commutation failure which is analogous to the sparking of the commutator.

So far, in discussing the theory of commutation, we have referred only to operation within the normal range of speed. It was shown that commutation takes place as a result of electromotive forces in the motor circuit. At starting and very low speeds, however, there is insufficient electromotive force in the motor windings to cause commutation in accordance with the theory that has been given. This is one of the reasons for using the arrangement shown in Fig. 1 where the same tubes are used for rectification and commutation at the same time rather than the arrangement in Fig. 3 where separate tubes are used for rectification and commutation. The first arrangement provides commutation at standstill and low speeds, whereas the second arrangement does not. The reason for this is that while commutation, depending upon electromotive force in the motor circuit, does not function at low speeds, each tube in the arrangement of Fig. 1 is associated with the power circuit as well as the motor circuit and therefore while the electromotive force in the motor circuit is absent, the commutation is caused by the electromotive force in the power circuit. Thus there are two kinds of commutation, one caused by the electromotive forces in the motor circuit when used at full speed, and the other caused by electromotive forces in the power circuit which are effective at standstill and low speeds.

In the first case the commutation is initiated by the voltage in the grid and timed by the distributor. The timing of this commutation is accurate and is controlled by the grid circuit and may be called the grid commutation.

The other type of commutation which is effective at standstill and low speeds is not so accurately timed by the distributor. When the grid goes negative as the result of interruption of the distributor contact, this does not in itself cause any change in the power circuit. The current continues to flow as before until the electromotive force in the power circuit passes through zero and thus interrupts the current in one tube and transfers it to another tube which sometime earlier has been made conductive by the grid circuit. Thus it can be seen that it is the voltage of the anode and not the voltage of the grid that determines the time

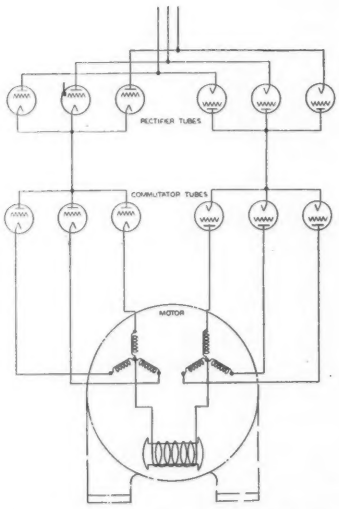


Fig. 3. Equivalent circuit with separate rectifying and commutating tubes

when commutation takes place. This may be called anode commutation. The anode commutation is fully effective at standstill but begins to lose its effectiveness at from one-third to one-half speed because of the inaccurate timing.

Operating Characteristics

The operating characteristics of the thyratron motor may be compared with the steam engine better than with any other electric motor. The phase shifter in the grid circuit, which is used by the operator for starting the motor and adjusting the speed, admits to the motor the current needed to produce the desired power and may appropriately be called a throttle control. The resistance used for speed control of slip ring induction motors might also be called throttle control, but the throttling in the thyratron motor is accomplished by a reduction power factor instead of by wasting energy.

The throttle control, which is a function of the grid circuit, lends itself well to automatic control. One feature of automatic control which has been incorporated in the commercial motor design is of particular interest because of its effect upon reliability and continuity of operation. Up to full power of the motor of 400 hp., the throttle remains wide open when set in the "full on" position, but if the load is increased so that the motor draws more than full load coming from the line, this current reacts upon the grid circuit in such a way as to modify the phase displacement of the grid voltage independently of the phase determined by the position of the controller. The effect of this reaction of the line current upon the grid control is to limit the current which the motor can draw from the line. This automatic current limiting control has been developed in such a way that the motor may be started from standstill with the throttle control wide open without drawing any more over-load current from the line than that for which the apparatus is adapted and less than that for which the automatic circuit breaker is adjusted. The starting of the motor may thus be made entirely automatic from a remote point if desired.

The motor is extremely reliable in its operation. It has decided stability of commutation. If a momentary commutation failure results in further accumulated changes of the functioning of the system and results in a short circuit, the commutation is unstable. When, on the other hand, such proportions of design have been observed that stable commutation has been established, it should be possible to disturb this normal operation momentarily in almost any way whatever and normal operation should resume itself immediately when the cause of the disturbance has been removed. The stability of commutation may be tested by purposely introducing such disturbances as open circuiting the power supply, interruption of the grid circuit or misadjustment of the brushes on the distributor. If any one tube is removed from the circuit, the current will be carried by the adjacent tubes and operation is possible at reduced load. The current in any one tube may be interrupted during operation by disconnecting the grid circuit and such a measure may be used as a preliminary step to remove the tube should it prove defective. Fluctuations of the voltage in the power supply will not cause any disturbances of operation but will only modify the speed torque characteristic as with a d.c. motor. Neither will unbalancing of the phases disturb operation. In fact one phase may be disconnected entirely and the motor will run on single phase power with reduced load. Since the power flow through the thyratron is irreversible, a short circuit on the power system will not tend to stop the motor. If on the other hand it is desired to use the motor as an electric brake it is possible to so arrange the control that the power will flow from the motor back into the line.

An improvement in the protection of an overhead transmission line against lightning can often be obtained by laying an additional wire on the ground underneath it. At the Westinghouse Laboratory, Trafford, Pa., artificial lightning strokes of 840,000 v. were applied to one overhead grounded wire of a specially built transmission line about a half-mile long. The voltage across the insulation supporting the line wire was measured to determine the protection afforded by an overhead ground wire against line flashover and outage. With the "counterpoise", as the wire lying on the ground is called, connected to the overhead ground wire, greater protection against line flashover is obtained when lightning strikes the overhead ground wire.

Further Discussion of Interconnection *of* Power Systems

By A. G. Christie

Professor of Mechanical Engineering
the Johns Hopkins University

YOUR EDITOR has started the discussion of a subject of great importance to all power engineers. Its import to the American people at the present time would justify full and ample consideration of its technical and financial aspects. However, interconnection has many angles and each instance of interconnection appears to require special consideration. It is therefore difficult to generalize on such a subject and details of every case cannot be presented.

Those who have studied utility problems agree that there can be no single rate throughout the whole country unless cost figures are practically ignored. It costs different amounts to provide service in different localities and even to different classes of consumers. One of the chief difficulties of the problem of interconnection lies in this cost of producing energy.

Consider first the interconnection of a privately owned plant—say an industrial plant—with an electrical distribution system. If this industrial plant can furnish random service only at odd hours and cannot be depended upon to carry a portion of the daily and annual peaks of the system, then the value of energy furnished by this industrial plant is the incremental cost of developing the same energy in the system's plants. This value in general would amount to little more than the coal cost to the utility.

Suppose, however, that the industrial plant can be depended upon for peak load and emergency reserve service to such an extent that less peak load and reserve capacity need be carried by the utility system, then the interconnection has greater value than the incremental cost of energy. The industrial plant is entitled to additional remuneration approaching in value the fixed charges on the reserve equipment thereby provided and also for certain labor and maintenance expenses.

Similar differences in the value of interchanged energy exist in the case of interconnected utilities and this has been the reason why small amounts of power have been exchanged over certain of the existing interconnections. The question that fixes the value of such energy is, "Is this interchanged energy firm power or surplus energy?"

There are cases where a large interconnected system is operated from a central control station and where each additional load requirement is met from the available station on the system having the lowest incremental cost. Each local system bears its own fixed charges and an agreement covers the costs of the system's stand-by reserve.

The question has often arisen regarding the value of water power, interconnected to a system, with steam generating stations. Both steam-power and water-power costs vary over a period of years. In the case of the steam plant, coal prices fluctuate, daily load curves and yearly load factors change, and even labor and maintenance costs are not fixed. In water-power plants, output is dependent upon storage, character of run-off and duration of low water periods. The character of the system load determines the amount of firm power furnished by water throughout the year and also the amount of secondary energy.

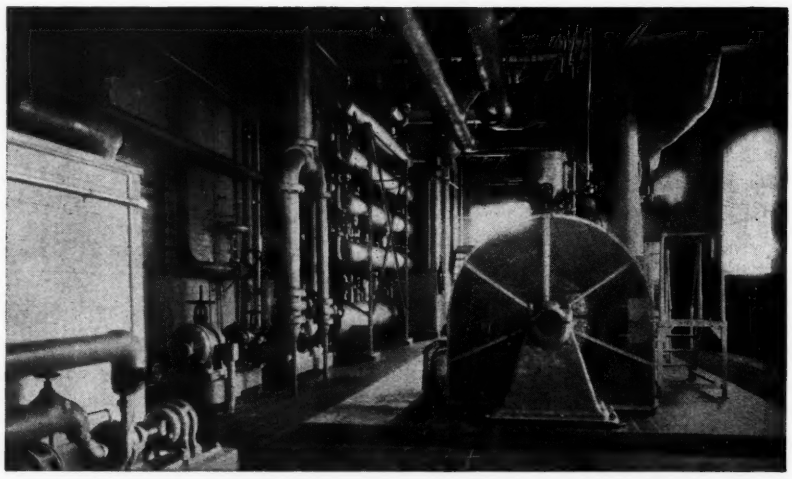
The secondary power has only an incremental value. The firm power may be valued, as in some cases, at the cost of equivalent steam power plant or at the actual cost of the hydro development. These have been found to vary widely in certain cases. It will be obvious that water power may not be cheap if the firm power in hydro plants is assessed at the equivalent value of a steam plant.

There are many cases where arrangements for interconnection of steam and water power have been effected with profit to both parties. There are cases where hydro systems have been provided with hydro reserve capacity at costs that appear greater than that of stand-by steam plants. These may be due to differences of viewpoint on the economies of the situation. Thus in Canada, hydro developments for stand-by are favored in place of importing foreign coal.

The writer has had to consider many of these interconnection problems and each has generally resolved itself into an individual case greatly affected by local considerations. For instance, it was proposed to interconnect a hydro system with a steam system located in the coal fields so that an outlet might be secured for secondary hydro power at a profit to both seller and user and also so that both systems could furnish each other with emergency service.

Strenuous objection to this arrangement was made by local interests. These held that without interconnection, the coal fields would be further developed and the cost of power would largely consist of local wage payments thereby increasing local prosperity. If water power were used, power costs would consist largely of fixed charges and sinking funds on the hydro development and transmission lines which money would go to capitalists in the East and also abroad, and this money would act as a drain on local prosperity.

Interconnection of systems is in general desirable and advantageous. However, as intimated above the agreements covering such interconnections are not simple and local factors must be given proper thought.



Motor characteristics must be fitted to the machine in modern refrigeration plants

Refrigeration Machinery
Motor Drives *and* Control

Part II.* Pumps, Fans and Compressors Have Different Characteristics Which Must Be Considered When Buying Motors. By R. C. Allen, General Engineer, Westinghouse Elec. & Mfg. Co.

SOME SPECIAL MOTOR DESIGNS have been so widely used that they have been made standard and are now the motors commonly used. This is true of the so-called linestart, or full voltage starting motors, which have torque characteristics designed for specific types of drives and for this reason warrant special attention.

Types of linestart motors are: I, standard torques for general drives; II, high torque for compressors and the like; III, low torque (above 30 hp.) for centrifugal pumps and fans.

Figure 6 shows curves of these as Class I, Class II and Class III respectively. There is also shown for comparison the older design or general purpose motor which had higher torques and starting currents. Figure 7 also shows the same motors with the current curves added, note the peak or starting current value for the different types.

Objection to high starting currents is primarily the effect on the power lines particularly in network systems where the lights and power are on the same feeders. A quick and large change in line current is likely to cause voltage changes, due to line drop, that may be noticeable and objectionable to those using lights fed from the same source. Where the lights and power feeders are from separate transformers the power companies are or may be more liberal regarding al-

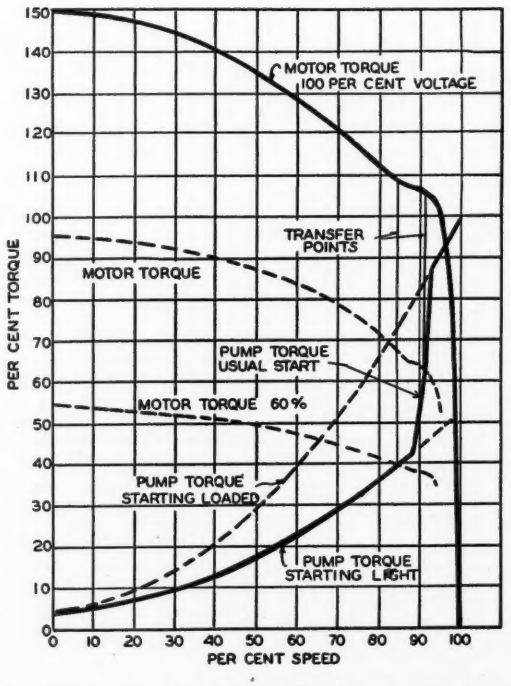


Fig. 1. Torque variation of a centrifugal pump and also of a synchronous motor for 60, 80 and 100 per cent voltage (Reproduced from Part I, February issue)

*Part I appeared in the February issue, page 117.

lowable starting current. Reduced starting current can be obtained by reducing the voltage at the motor terminals by use of a starter involving an auto transformer, resistance, or reactor.

Current taken from the line depends upon the type of starter used but the torques delivered by the motor are always in proportion to the square of the ratio of the voltage applied to the motor and the rated motor voltage. This means that for 80 per cent voltage at the motor the torque would be 64 per cent (0.80 squared) of the rated torque. The line current would also be 64 per cent of the normal starting current for an auto transformer type starter but 80 per cent of normal for the resistance or reactor type starter. The reactor starter gives better voltage characteristics as full speed is approached and is therefore used in preference to resistance starters on the larger motors. Smaller motors use the resistance starter as being equally satisfactory and cheaper.

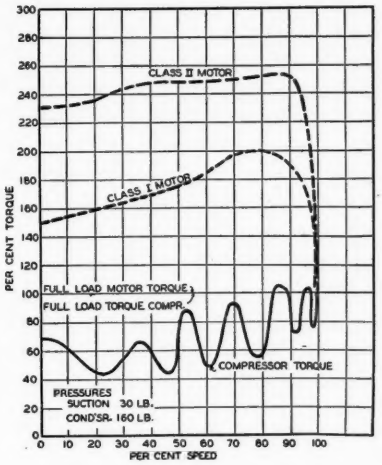
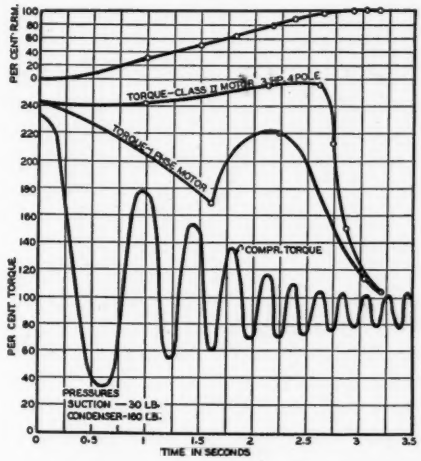


Fig. 2. (Left) Torque of an ammonia compressor starting under load (Reproduced from Part I, February issue)

Fig. 3. (Right) Torque of an ammonia compressor starting unloaded (Reproduced from Part I, February issue)



From the foregoing it is evident that squirrel cage motors with low starting torques can in general be used for driving centrifugal pumps and fans and that high torque motors are required for drives like the reciprocating compressor unless adequately unloaded. Curves Figs. 2 and 3 show tests run on a single cylinder compressor with the speed torque curves of the motors used plotted also to show the reason for the motor choice. It will be noted that these curves are based on time or speed (for the abscissae) with the torque shown vertical (ordinate) which is the reverse from the standard motor curves.

In the squirrel cage motor the characteristics are fixed by the design and cannot be changed, to any extent, after the motor is built. The different characteristics are secured principally by the change in rotor or squirrel cage construction or design and to change the design of the motor requires a new rotor at least.

With the wound rotor motor the starting and operating characteristics can be changed by use of external resistance connected to the rotor winding by the slip rings. Varying this external resistance will change the starting torque and the resulting starting current, Fig. 8.

With no external resistance, that is with the rotor ring short circuited, the speed torque curve is essentially the same as for the general purpose squirrel cage motor. Introducing resistance in the rotor circuit lowers the curve by increasing the slip, that is reducing the motor speed for corresponding load or torque values. For a number of different resistances obtained from the controller points, there would be a corresponding number of curves. The controller point determines the speed torque characteristics of the motor, the load determines the torque, and the torque determines the speed point on that curve.

This is why a driven load can be operated at different reduced speeds by simply notching the controller. Greater secondary resistance gives a lower curve or per cent slip for the load torque. The load torque may be the same at reduced speeds, as for a gear type of pump operating at constant pressure (called a constant torque application) or different at reduced speeds, as for the centrifugal pump or fan (called a varying torque application).

On the curve Fig. 8 is shown also the load torque curve of a fan (with fan friction neglected). The speed of the fan will be determined by the point at which the fan torque curve crosses the motor torque curve for the particular control setting. It will be noted that for 50 per cent speed the motor torque curve becomes very steep, consequently a change in fan operating conditions giving a different torque will give a radical change in speed that will effect the fan output. This may or may not be objectionable.

Torque, and also the starting current, at the instant of start depends upon the total resistance in the rotor circuit for the first controller point. Generally this is selected between ¾ and 1¼ full load torque for centrifugal pumps and between 1.5 to 2.5 times full load torque for reciprocating compressors and the like. The starting current under these conditions is practically proportional to the starting torque and smooth acceleration can be obtained by the correct selection of the number of starting controller points. It is evident that for a certain delivered torque, lower starting currents can be secured with wound rotor motors than with squirrel cage motors. A squirrel cage motor and control can however generally be selected to meet the required starting current and torque conditions.

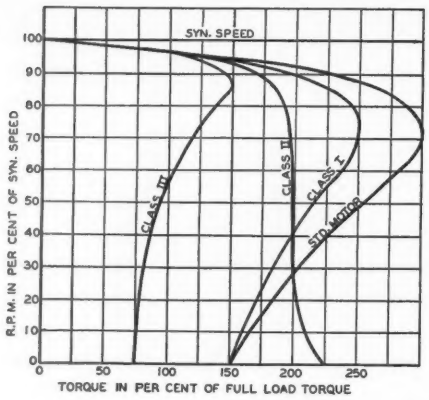
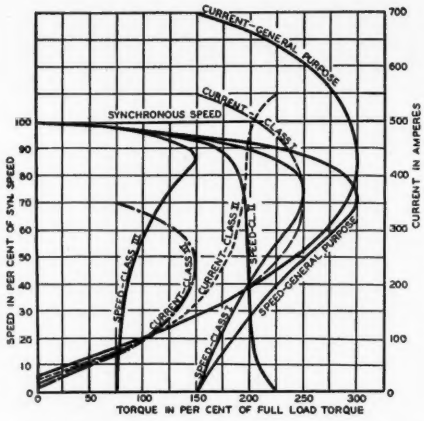


Fig. 6. (Left) Torque curves of three types of line start motors

Fig. 7. (Right) Torque and current curves for three types of line start motors compared to the older general purpose motor



Application for the wound rotor motor is particularly for those drives requiring reduced speed operating condiitons, such as ventilating fans, and where the starting torque requirements are higher than can be secured from the squirrel cage motor.

With the synchronous motor, it is possible to design the starting characteristics obtained from the squirrel cage winding of the rotor, more or less independently of the running characteristics, so quite a variety of motor designs are available for slow and high speed compressors, centrifugal pumps and blowers, for full voltage starting. In operation, while accelerating, the motor characteristics are similar to those of the squirrel cage motor since it is the squirrel cage winding that is producing the accelerating torque.

The curves for the synchronous motor in Fig. 1 show one type of accelerating speed torque curve where reduced voltage is to be used. It illustrates also how, at reduced voltage, the motor torque curve crosses the load torque curve. At this point is is necessary to transfer to full voltage to continue accelerating to full speed. The vertical line indicates the transfer from one torque curve to the other.

Synchronizing, by energizing the motor d.c. field, can be done after the motor reaches approximately 95 per cent of full load (synchronous speed). It will be noted that this could be done with 80 per cent voltage for a pump started unloaded but requires full voltage for pump started loaded. The speed torque curve for the motor after being synchronized would be a straight line (vertical at 100 per cent) extending to the pull out point.

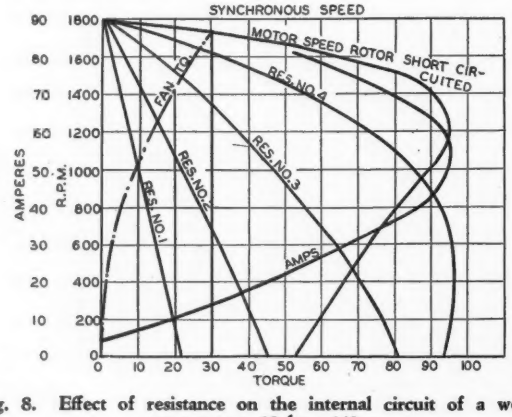


Fig. 8. Effect of resistance on the internal circuit of a wound rotor motor, 10 hp., 440 v.

With d.c., the compound wound motor is seldom required except for such drives as hoists and elevators and is not considered desirable for fans and pumps or even compressor drives as it has a greater speed variation in its load range than does the shunt motor.

There are also other variations in motor ratings and design that are available if desired and may have to be considered for special applications. These might be classed as:

TIME RATING: Continuous, 24 hr., 40 deg. C. rise; intermittent, ½ hr., 55 deg. C. rise.

HOUSING: Open, 24 hr., 40 deg. C. rise; enclosed; fan cooled; drip-proof; explosion resisting.

WINDING: Standard impregnation of windings; excess moisture impregnation; acid fumes resisting impregnation.

TYPE OF DRIVE: Coupled; belt; engine or direct mounted.

With controls there is even a greater possible variation since controls can, if necessary, be made special for meeting certain conditions, standard controls are, however, available for the usual drives. These can be grouped as follows:

STARTING SCHEME
- Full voltage
- Reduced voltage
  - Auto transformer
  - Resistor
    - Primary
    - Secondary
  - Reactor

METHOD OF OPERATION
- Hand
  - Manual
  - Pushbutton
- Automatic
  - Pushbutton
  - Full automatic
    - Float switch
    - Pressure governor

PROTECTION OR SAFETY FEATURES
- Overload trip
  - Thermal
  - Dash pot
  - Induction relays
- Under voltage trip
  - Protection (for machine tools, etc.)
    - Instantaneous or delayed
  - Release (for full automatic controls)
- Loss of phase
  - Secured by operation of overload
- Loss of synchronous motor field
  - Secured by operation of overload trip

METHODS OF ACCELERATION
- Definite time limit
- Current limit

Although it is evident that there is a great variety of motors and controls, the motor manufacturer has endeavored to standardize on designs which meet the requiremets of the various drives and operating conditions found in the refrigeration industry, so that, knowing what it is desired to accomplish, it is not difficult to determine the most suitable motor and control.

Why Analyze Auxiliary Power Costs?

By H. S. KNOWLTON

IF OVERHEAD charges are set aside to limit the field of discussion, electricity can be produced at a surprisingly low cost per kilowatt-hour in most modern generating plants. By the same token energy purchased for block delivery to station buses usually is billed at figures which make unit costs seem small to operating plant engineers. In many power systems, therefore, the internal use of electricity has gradually developed into considerable volumes without much thought of its cost, and if one comes face to face with the totals of annual consumption for auxiliary purposes in plants, substations and offices the results are sometimes a bit startling.

Consider the data in Table (I) which gives the auxiliary energy usage in five eastern power systems during 1933:

Table I. Use of Auxiliary Energy in Five Selected Power Systems

	Kilowatt-Hours		Kilowatt-Hours Consumed by Company in		
System	Total Generated	Total Generated and Purchased	(a) Generating Stations	(b) Substations	(c) All Company Usage
1	61,466,100	121,269,330	3,885,600	408,804	4,760,063
2	850,709,910	1,009,722,755	26,411,416	5,970,592	37,371,475
3	1,343,400	86,514,639	139,726	180,057	530,923
4	46,228,500	51,377,551	3,047,680	94,738	3,142,418
5	263,801,710	374,531,069	1,131,080	383,588	1,669,418
	1,223,549,610	1,643,415,344	34,615,502	7,037,779	47,474,297

In these systems the total auxiliary energy used in power plant, substation and company offices (including service stations, etc.), aggregated about 2.9 per cent of the total energy delivered at the buses for the group. The value of this electricity at an average production cost of 5 mills per kilowatt-hour totaled $237,000 and at 1 cent per kilowatt-hour closely approached half a million dollars! System 1 has an interior steam plant which has been in a stage of evolution ever since it was built; System 2 operates two tidewater steam stations; System 3 buys nearly all its supply of energy from an affiliated company's tidewater plant; System 4 operates an old but efficient steam station located on tidewater and interconnected with a chain of affiliated steam and hydro plants through an intermediate independent company; and System 5 operates three hydro stations also interconnected with other facilities. Actually, all the companies included are interconnected by a far-flung regional transmission network under four dominant interests.

Having seen the potential value of economical use of energy in the group of plants embraced in the table, it may be illuminating to consider a few percentage ratios. These will bring out the differences in individual plants and systems a little better than total figures. Table II is significant.

Table II. Percentages of Auxiliary Energy Consumed

System	Generating Plants to Energy Generated	Substations to Total Energy at All Buses	All Company Use to Total Energy at All Buses
1	6.35	0.34	3.9
2	3.1	0.6	3.7
3	10.3	0.21	0.6
4	6.6	0.18	6.1
5	0.43	0.10	0.44
Averages	2.84	0.42	2.9

The remarkable variations existing in ratios are sufficient reason for making studies of auxiliary energy usage as time permits in local plants, substations and other property of the producer of electricity. The elements of plant and substation design affect the results, of course. The extent to which steam-driven and motor-driven auxiliaries are employed; the amount of lighting circuit subdivision provided and switching practice in connection with it; the care with which auxiliary equipment is cut in and out of service in relation to loads or left to run for periods of subnormal efficiency; the fitness of particular auxiliaries for the plant conditions through a long period of service and load developments; willingness of the management to replace inefficient auxiliaries by units better adapted to later economic conditions; the handling of substations and extent to which power is generated and purchased—all these things challenge analysis in taking up the use of energy internally in plants, substations and other property. Simple layouts mean less energy consumed in auxiliary service in many cases, as in a hydro plant with turbine-driven exciters set against a steam station with many refinements in equipment provided for the sake of overall economies. System 3 used about 25 times as much energy in the steam plant auxiliaries as did System 5, for example.

One might continue this sort of analytical comment, but enough has been said to indicate the interest of making comparisons and getting at the major reasons for striking differences if possible. Beyond this come the engineering and operating remedies, if any. Some cases cannot be handled without equipment changes, if results of moment are to be had; but in others a closer scrutiny of operating practices and the establishment and maintenance of more frugality in the use of energy, will bear good fruit. Even in a hydro plant where water would spill if not used to produce energy for internal service, electrical service is not free of cost, for lamps and other apparatus have useful life shortened by doing work. Operating engineers with a bent for economic study will find the use of auxiliary energy a fascinating and worth-while objective in many plants and substations.

As One Engineer to Another—

G. F. Discusses Steam and Vapor with the Chief. By G. F. WETZEL, M. E.

AFTER THE PREVIOUS talks, my friend, the Chief, realized that he was getting pretty rusty on the theory underlying his work, and the laws and data which changing conditions might require him to use almost any time. When I told him that we could get together at intervals to go over some of these subjects he was "all steamed up and rarin' to go."

When I got to his office next day his desk was cleared for action, with a supply of blank paper handy, and he was apparently ready for me.

"Hello, Chief, here I am again," I greeted him. "And how is your receptivity this p. m.?"

"Hello, yourself, G.F." he returned. "And do I look like a radio set?"

"As a gentleman, I would not like to comment on your looks,—but you better get tuned in with station S-T-E-A-M, because a lot of high grade information is going to be broadcast this afternoon, so set your dials, —and here we go.

"I am going to assume, to be on the safe side, that you don't know much about steam, and give you a little lecture about it from the ground up. Then we will illustrate what we have been over with some examples.

"To get started, let's assume that we have a pound of steam at a temperature of 0 degrees F., and refer to the graph. Point A represents this condition. Now suppose that heat is added to the ice so that its temperature is raised. According to the available figures, it will take just about half a B.t.u. to increase the temperature one degree, or 16.13 B.t.u. to raise the temperature to 32 deg. We then come to a point B where the continued addition of heat does not raise the temperature a bit, but does start to melt the ice. After 144 B.t.u. more have been added, we no longer have ice, but a pound of real ice water at 32 deg., taking us to point C. This change from ice to water is a change of state and remember, whenever water changes its state of being, a considerable quantity of heat is involved. If the same quantity of heat were removed, the water at 32 deg. would change back into ice. In other words, this change of state is a reversible process, depending on whether heat is added or removed. The amount of heat involved in this change is called the Latent Heat of Fusion."

"Just a minute, G.F.," the Chief interrupted, "You mentioned a certain number of B.t.u.'s. Last time we talked about B.t.u.'s too. Now I'm going to be just as dumb as you like to pretend you think I am, and ask just what a B.t.u. is? I've used the letters lots of times, but now I want to be sure of every detail, since we are getting down to brass tacks."

"Okay, Chief," I returned, "Generally speaking, a B.t.u.—that is, a British Thermal Unit—is the quantity of heat which will raise the temperature of 1 lb. of water 1 deg. F. Getting more specific, a B.t.u. is the amount of heat required to raise the temperature of 1 lb. of water from 62 deg. F. to 63 deg. F., or is 1/180 of the amount of heat necessary to raise the temperature of 1 lb. of water from 32 deg. F. (freezing) to atmospheric boiling point. The reason we have to be so precise is that the specific heat of water changes at different temperatures between freezing and boiling, part of the time being slightly less than 1 and part of the time a little over 1.

"Referring to the chart again, at point C we have 1 lb. of water at 32 deg. F. Adding heat, the temperature will go up at the average rate of one degree per B.t.u. If this is kept up until 180 B.t.u. have been absorbed by the water, it will reach a temperature of 212 deg. F., which of course, is 180 deg. above freezing point, and we are at point D.

"Point C is taken as the base or starting point for all heat measurements pertaining to steam—that is all heat quantities in steam are measured above 32 deg., freezing point.

"The heat represented by the horizontal distance between C and D is called the Heat of the Liquid, or Sensible Heat. This can be measured directly by its effect on the temperature of the water. It might be defined as the amount of heat put into the water between freezing and boiling points. In case the temperature of water is not as high as the atmospheric boiling point (or any higher boiling point), the heat of the liquid is the heat needed to raise the water from freezing to the observed temperature.

"When D is reached and we continue to add heat, the temperature is not affected until a large amount of heat has been absorbed, 970.4 B.t.u., more than five times as much heat as was needed to bring the pound of water from freezing to atmospheric boiling point. While the water is absorbing all this heat, its volume is changing from about 28 cu. in. to 26.82 cu. ft., or increasing sixteen hundred times. That is to say, the water has again changed its state, from liquid to vapor or steam. This change is reversible, the same as the ice-to-water or water-to-ice change. The change from water to steam required the input of 970.4 B.t.u. and conversely, if the pound of steam at atmospheric pressure is condensed, the same amount heat will be given up and be available for heating or, if put through suitable equipment, for developing mechanical energy. The length D to E on the chart represents this quantity of heat, and is called the Latent Heat of Evaporation, or many times referred to simply as Latent Heat. Latent

heat, by the way, is a good name for it, for it is actually latent, not being detectable by the thermometer at all, and being absorbed or returned by the steam or water, as the case may be, without any change in its temperature.

"At E our original pound of water has been entirely changed to saturated steam at atmospheric pressure, and—"

"Just a minute, G.F." interrupted the Chief. "Several times you have mentioned atmospheric boiling point and atmospheric pressure. Why bring that up? And just exactly what do you mean by saturated steam?"

"Those are sensible questions, Chief, and we might just as well straighten that out now. There is a definite reason for specifying atmospheric conditions. In the first place, there are several characteristics you must remember about steam; the latent heat is different at every pressure; the temperature is different at every pressure, as there is a definite temperature for every pressure between a perfect vacuum and the critical pressure or maximum possible saturated steam pressure, which I will explain later on; there are definite values of heat of the liquid, total heat, specific volume and specific weight for every temperature between freezing point and the critical temperature. Therefore in giving the value of 970.4 B.t.u. for the latent heat of evaporation, one must specify the temperature or pressure as atmospheric pressure or atmospheric boiling point. Dumb as you are, Chief, you probably recognize the fact that boiling point is the temperature at which water changes into steam."

"Don't be so d—d sarcastic, G.F.!" the Chief exclaimed. "I know I'm dumb, but you don't have to rub it in. I'm straining my brains now to follow this stuff through, but by golly, I'm going to get it or know the reason why!"

"That's the spirit, Chief," I said, "But just keep calm, and let's get your questions answered. It's most important to remember that for every saturated steam pressure there is a corresponding temperature, and for every saturated steam temperature there is a corresponding pressure. This holds true whether the temperature is 40 deg. or 700. You have already referred to steam tables, so you probably realize that by taking any value of temperature between 32 and 706 deg., or any pressure from 0.0887 to 3226 lb. per square inch absolute, you automatically specify all the other data for that condition, and by referring to the steam tables can readily look up the values.

"Now, answering your question about saturated steam, this is merely dry steam with its temperature corresponding to its pressure, or vice versa, pressure corresponding to temperatures. To save you the trouble of thinking up and asking the question, 'How can dry steam be saturated steam?' let me say that the term saturated as applied to steam means complete or perfect or balanced steam, and does not refer at all to the condition you would be in if you fell in the lake,—wet!"

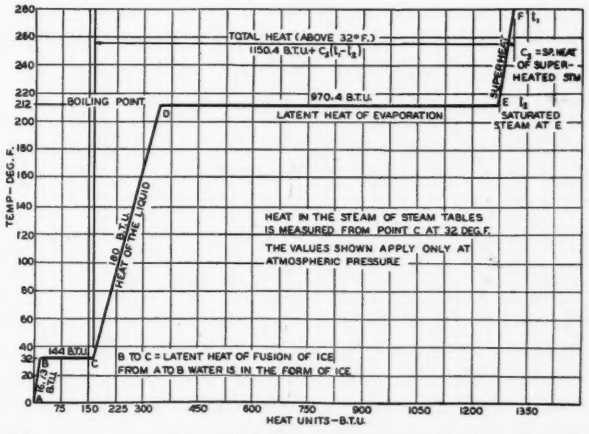
"Are you a little cuckoo, G.F." again the Chief interrupted, "Talking about a boiling temperature of 40 deg.? One of my firemen once told me that steam is water gone crazy with the heat, and I'm beginning to believe him! And just what do you mean by specific weight, and specific volume,—and do you mean to say there is no such thing as wet steam?"

I could see that the Chief had made mental notes of several items that had puzzled him somewhat, and was trying hard to get the picture of Steam clearly,—but his questions came so fast that I had to tell him to be patient and take them one at a time.

"I'll take your questions in order, Chief," I continued, "And I assure you that I am quite in my right mind. Now as to your question about water boiling at 40 deg., of course it can boil at 40 deg. F. just as truly as at 212 deg., or for that matter, at 350 deg. Remember what I told you about pressure corresponding to temperature. Look at your steam tables and give me the pressure of 40-deg. saturated steam."

He looked at his steam tables and gave me the value,— 0.1219 lb. per square inch absolute, or 0.2478 in. of mecury pressure.

"That means, in terms with which you may be more familiar, a vacuum of 29.67 in.," I told him, "And an interesting application of that fact is in the Decalorator, in which just using plain water as the refrigerant, this condition exists when it is cooling the water to 40 deg. I'll give you a detailed description of that one of these days. That, by the way, is the type of equipment that is used to do the cooling in the air-conditioning plant of the Chicago



Temperature—heat chart for ice, water, saturated and superheated steam

Tribune Tower. Remember, once more—pressure of saturated steam corresponds to its temperature, not sometimes, but all the time, between the limits I mentioned. Another thing to keep in mind is that steam is water vapor and nothing else, between the same limits. It is true that above 212 deg. and 14.9 lb. per square inch absolute it is called steam, and below atmospheric boiling point and pressure it is usually referred to as vapor. But this is purely an arbitrary division, as you can see from your steam tables that there is no difference in the kind of information given above or below atmospheric pressure and temperature except that below, pressures are given in both pounds per square inch absolute and inches of mercury.

"Next question! What is meant by Specific Weight? Specific weight is the weight of a unit volume of substance. Since we are dealing with steam, in this case, it would mean the weight in pounds of

1 cu. ft. of steam. You can readily appreciate the fact that this will be different for every pressure, because the higher the pressure the more steam will be crowded into each cubic foot and consequently the greater the weight.

"Specific volume is the converse of specific weight, being the number of cubic feet per pound. This will vary inversely with changing pressure—becoming less as the pressure increases, which is obvious because if each cubic foot weighs more, it will take fewer cubic feet to weigh a pound.

"Answering your question about wet steam, of course there is such a thing as wet steam. But it has nothing to do with saturated steam. Wet steam is a mechanical mixture of dry saturated steam and unevaporated water. It is described by specifying its quality, which is given as a percentage. This percentage is the percentage by weight of dry steam in the mixture. Thus 97 percent quality steam would mean 0.97 dry saturated steam and 0.03 liquid water, both at the same temperature. Wet steam will not have the same heat content as dry steam because the unevaporated water will contain only heat of the liquid, and no latent heat. We will go into the calculation of the heat in wet steam a little later.

"We have mentioned three states in which water is found—solid (ice), liquid (water), vapor (steam). There is another condition which is not exactly a change of state because it is still vaporous though different from saturated steam, namely, superheated steam. You will recall that we talked briefly about that during one of my previous visits, and said it was simply overheated steam. Steam at any pressure and temperature between the conditions at freezing and the critical values may be superheated. For example, right here in this office we have superheated steam."

At this statement the Chief sniffed the air as if he almost expected it to burn him, and exclaimed, "Superheated steam here in the air—nuts!"

"Just for that crack, Chief, you are going to tell me just why it is true that there is superheated steam or vapor right here in the office atmosphere," I returned. "Take a piece of paper and put down the values I ask for, out of your steam tables. Assume the relative humidity here is 30 percent."

After telling him what was wanted, and giving him time to look up the values, he handed me his paper with this information, a somewhat sheepish grin on his face:

Room temperature 76 deg. F. Saturated steam pressure at 75 deg. 0.444 lb. per sq. in.

$0.30 \times 0.4440 = 0.1332$ lb. per sq. in. pressure of steam or vapor at 30 percent relative humidity.

Saturated temperature corresponding to 0.1332 lb., 42 deg. F.

Degrees of superheat, $76 - 42 = 34$ deg.

"We are getting somewhat ahead of ourselves by bringing relative humidity in at this time," I explained, "But I wanted to impress on you the significance and meaning of superheated steam. Remember it is nothing but water vapor heated to a temperature above that corresponding to its pressure. Its specific heat will range from approximately 0.46 to 0.68, depending on its pressure and amount of superheat. When steam is overheated or superheated naturally its heat content is increased, and it will give up its superheat and return to the saturated condition, when cooled, before any of it is condensed."

Here the Chief reminded me about the explanation of wet steam heat values, so I told him—"Before we go into wet steam let's go over saturated steam values. The total heat is the sum of the sensible heat of heat of the liquid, the latent heat of evaporation, and the superheat, if any. Certain letters are usually used to represent the different quantities:

r—latent heat
q—heat of the liquid
H—total heat
C_s—specific heat of superheated steam
t_1—temperature of superheated steam
t_2—temperature of saturated steam.

Putting it in equation form we have:

$$H = r + q + C_s (t_1 - t_2)$$

For dry saturated steam:

$$H = r + q$$

"If the steam is wet, the quality is usually represented by x, this being the percentage of dry steam in the mixture. The liquid water being unevaporated has no latent heat, only heat of the liquid. This cuts down the total heat in a pound of wet steam by the amount of latent heat it is short. This is expressed like this:

$$H = xr + q$$

"To illustrate, dry saturated steam at 40 lb. absolute has $r = 933.3$ B.t.u., $q = 235.93$ B.t.u., $H = 1169.2$ B.t.u.

If quality is 95 per cent then

$$H = 0.95 \times 933.3 + 235.93 \text{ B.t.u.}$$
$$H = 886.6 + 235.93 = 1122.53 \text{ B.t.u.}$$

So you see it is not at all difficult to get the numerical values.

"We seldom calculate the value of H for superheated steam as it is necessary to have a table of specific heats for various pressures, and the steam tables give the values for total heat, if you know the temperature of the superheated steam, or the degrees of superheat, and the pressure of the steam.

"Saturated steam that has been expanded in steam cylinders is always wet, containing moisture, and that which flows at high velocities or through poorly insulated pipes will many times carry entrained water. Boilers working at a high rate will sometimes deliver wet steam."

"I want to ask another question, G.F." the Chief said. "What did you mean when you mentioned critical temperature and critical pressure?"

"Fair enough," I answered, "That does require some explaining. As the temperature and pressure of saturated steam increase, the steam gets more and more dense until finally a point is reached where the pressure is so great that the steam is just as dense or solid as the water. The latent heat decreases quite rapidly as the critical pressure is approached until at that point the latent heat becomes zero. The critical pressure is 3226 lb. per sq. in. and the corresponding temperature is 706.1 deg. F. A number of the larger and more modern generating plants use steam at a temperature of 700 deg. F., but being superheated

about 200 deg., the pressure will be around 700 lb. per square inch, far below the critical pressure.

"Here is a problem that will apply some of the facts about steam that we have been over: How many pounds of steam will it take to heat 1000 gal. of water per hour from 60 deg. to 140 deg.? Steam is at 20 lb. absolute, quality 96 per cent, Latent heat only is used and nothing allowed for heat losses.

"Here there are two heat quantities which are equal to each other: The heat received by the water; and the heat given up by the steam. Thus:

$$W \times (t_1 - t_2) = w \times xr$$

where W is weight of water in pounds, t_1 is final water temperature, t_2 is initial water temperature, w is weight of steam in pounds.

"Go ahead and figure it out."

The Chief went at it while I looked over some reports I was working on. I could see he was making progress, though at times he had to stop and think it out carefully. Then he handed me his paper.

$$1000 \times 8.33\ (140 - 60) = w \times 0.96 \times 959.9$$

$$w = 1000 \times 8.33 \times 80 \div 0.96 \times 959.9$$

$$w = 724 \text{ lb. of steam}$$

"Okay, Chief. Now suppose the condensate from the steam is cooled down to 180 deg., how much steam will be needed? See if you can get it all by yourself."

After a short while, he again handed me his paper and I was pleased to see that he had gotten the right idea.

$$1000 \times 8.33\ (140 - 60) = w\ [0.96 \times 959.9 + (227.96 - 180)]$$

$$w = (1000 \times 8.33 \times 80) \div [(0.96 \times 959.9) + 47.96]$$

$$= (8330 \times 80) \div (922 + 47.96)$$

$$w = 687 \text{ lb. of steam.}$$

Note: 227.96 is boiling temperature of steam at 20 lb. press. abs.

(227.96 — 180) is heat given up by condensate

8.33 is number of pounds water per gallon.

"Well Chief, have you had enough for today?" I asked him.

"I'll tell the world," was his answer. "All I want now is time to digest your broadcast, and hope that my receptivity is equal to the job."

"I guess it is, Chief. Next time we'll take up heat quantities and some problem analysis. It's time for me to be going, so good-bye. See you soon."

In connection with the matter of Instrumentation of Power Plants, treated in the issue of January, 1935, it will be of interest to readers to know that much work along the line of proper instruments and their use has been investigated by the Power Test Code Committee, of the A.S.M.E., and the results of the research have been embodied in their various reports. Among the reports are one on fluid meters, one on instruments and apparatus by Committee 19, besides much other material which appears in the body of the various Power Test Codes.

Tradition and the Ice Can

IN A CONTROVERSY over Flakice versus the standard 11 in. cake, Charles H. Herter of New York contributed, through Refrigerating Engineering, some pertinent remarks regarding the influence of tradition in the ice industry.

Cost of manufacturing ice was given as about $2.40 per t. and the cost of retail distribution about $4 per t. Adding an apparent profit of 25 per cent gives a total retail delivered sales price of at least $8 per t., or 40 cents per hundred pounds. Although the freezing time of standard 11 in. 300 lb. cake has been reduced from 65 to 32.5 hr., further reductions must be made if ice is to compete with mechanical refrigeration.

He suggested that the 300 lb. cans be harvested as soon as 150 lb. of ice is formed. With 12 deg. brine a 300 lb., 11 in. cake requires about 42 hr. to freeze while 150 lb. of ice, representing an ice coating of 2 in. thick on the five surfaces of the can, require only 6 hr. and a single can could be made to yield 525 lb. of ice per 24 hr.

This would reduce the can and tank cost about half. If the freezing time is extended to 12 hr. by using 22 deg. F. brine, a considerable saving in compressor power can be made. Clear ice would not be necessary. The hollow shells would be passed through a power driven ice breaker and broken to any desired degree. Small ice is more effective in air cooling and refrigerator work and he feels that this represents an excellent method of reducing ice costs for these services.

Improving Standing of Engineers

Improvement of the standing of professional engineers is sought by The Engineers' Council for Professional Development, a body created and sponsored by the national engineering and engineering educational societies. It aims to function in student selection and guidance through local agencies which will contact high school students and teachers; in engineering education through coöperation with faculties of engineering colleges to improve instruction and give recognition by accrediting satisfactory colleges; in professional development by aiding graduates in their reading and study after graduation; in professional recognition by establishing a system of certification of those who meet standard requirements, thus establishing a basis for granting of licenses, use of the professional title and granting of professional degrees by engineering colleges as a certification of post-graduate accomplishment.

One of the aims, as outlined by Dr. C. F. Hirshfeld before a joint meeting of engineering societies, is to bring the young graduate to a broader view and a well-rounded development, fitting him to play a larger part in social and economic affairs and to serve society broadly in proportion to his ability. The effect should be to arouse more fully the self-consciousness of engineers as to the importance of their profession and to establish engineers in their proper status in the social and economic structure of the country.

Excess Baggage *Carried by* Coal

Factors Influencing the Selection of Coal for Power House Use. By A. W. Thorson

SEVERAL articles have appeared in current technical literature concerning the comparison of coals and the necessity of checking their analyses periodically to insure the best supply of fuel. None of these, however, has emphasized the importance of variations in moisture and ash content, nor has proper consideration been given to the importance of ash softening temperature. Moisture and ash are generally recognized as having a bearing on the fuel value of coal, but their full significance is not generally appreciated. Before discussing moisture and ash more fully, the writer wishes to stress the importance of ash softening temperature on combustion and maintenance costs.

Effect of Ash Softening Temperature

For a given installation and combustion rate there will be a definite furnace temperature to which the coal ash is subjected. If the ash softening temperature is above this furnace temperature, no appreciable clinkering will be experienced, but as the softening temperature decreases below this furnace temperature, clinkering and maintenance costs will increase. The critical temperature value for the particular installation depends upon the maximum rate of combustion which may be imposed upon the boiler. Once this rate is decided upon, the corresponding temperature can be determined. The proper procedure is to restrict purchases to coals which are known to have an ash softening temperature above the critical for that installation.

It is obviously necessary periodically to check samples of these coals for ash fusion. This is even more important than checking ash content, as experience shows that there may be much wider percentage variations in ash softening temperature than in the ash content for coal coming from the same mine and seam.

It may, however, be uneconomical in certain localities to obtain coals with sufficiently high ash softening temperatures to avoid all clinkering. In other words, in districts where low fusion coals are locally available, high maintenance costs resulting from their use may be cheaper than high freight rates on more desirable coals. In such cases, an economic balance between coal and maintenance costs will determine the ash fusion standard which should be set as a minimum.

Ash is generally accepted as an undesirable constituent in coal, in that it dilutes the effective heating value of a unit weight of coal. But the full cost of ash is realized only by considering that the purchaser in addition to buying ash at the mine, must pay freight on it, and then pay for its disposal as refuse. The cost of ash disposal is often surprisingly high when the cost of crushing clinker, maintenance and power consumption on ash handling equipment, and transportation of refuse are considered. The cost is even higher in pulverized fuel plants where disposal of ash has not as yet been able to keep step with its accumulation for which valuable space must be provided. A detailed study of ash costs in any particular case will show just what premium the purchaser can afford to pay for low ash coals.

Effect of Moisture

The effect of moisture is analogous to that of ash. The moisture in coal when weighed at the shipping point must not only be bought at coal price but its transportation and disposal must also be paid for. The cost of removing moisture is particularly important when coal is stored out-of-doors where the moisture content may increase from say 3 per cent when stored to 5 or 6 per cent when burned by accumulation of rain or snow.

Moisture is usually considered unimportant because it evaporates in the furnace and produces no visible loss. This evaporation, however, and the subsequent super-heating to stack gas temperature, is done at the expense of the high potential heat in the coal which would otherwise be available for useful steam generation. The presence of moisture, therefore, means a direct reduction in the effective heating value of the coal.

The cost of moisture removal may be reduced by partially pre-drying the coal before entering the furnace in steam grid dryers. The economy results from the fact that moisture evaporated in the dryer leaves at saturated steam temperature at about amospheric pressure, whereas the moisture evaporated in the furnace must in addition be superheated to stack gas temperature. The amount of saving from pre-drying depends, of course, on the boiler efficiency and the cost of steam. The expense of high moisture content is sufficient to warrant any large coal consumer's attempt

to reduce moisture to the limit. This can be done first, by selecting coals which have a low inherent moisture at the mine, and second, by minimizing the use of storage coal. When coal is stored for emergencies, this coal should be left for purely emergency use, thus eliminating the consumption of more high moisture coal than necessary. When coal is stored because of seasonal or expected abnormal price variations, then the added expense of evaporating two to three per cent of excess moisture should be acknowledged when such a purchasing policy is adopted.

Cost Comparison of Competitive Coals

Consider, for example, two coals that have the same combustion characteristics, ash softening temperature, and combustible heating value, but different amounts of ash and moisture. A comparison of fuel costs on a heat equivalent basis will show the true effect of ash and moisture variations. Assume the heating value of both coals to be 15,000 B.t.u. per lb. on moisture and ash free basis. Coal A contains two per cent moisture, five per cent ash, and costs $4.00 per ton delivered. Coal B contains six per cent moisture, nine per cent ash, and costs $3.90 per ton delivered. The cost of ash handling is assumed to be 0.2 cents per one per cent ash per ton of coal. The following tabulation shows which of the coals to buy:

	Coal A	Coal B
Heating value of combustible, B.t.u. per lb.	15,000	15,000
Moisture, per cent as fired	2.0	6.0
Ash, per cent dry coal	5.0	9.0
Heating value as fired, B.t.u. per lb.	13,960	12,820
Heat to evaporate moisture in coal and superheat it to 350 deg. F. B.t.u. per lb. coal	20	70
Net heating value available for making steam, B.t.u. per lb.	13,940	12,750
Cost of coal, dollars per ton	4.00	3.90
Ash handling cost, dollars per ton coal	0.01	0.02
Total cost of coal, dollars per ton	4.01	3.92
Cost per million B.t.u. in coal, cents	14.40	15.30

The calculations show that Coal A, which was 2.5 per cent more expensive on price basis alone, is actually 5.9 per cent cheaper when proper consideration is given to the moisture and ash content of the two coals.

It is hoped that this brief discussion of some of the factors involved in the coal-purchasing problem will stimulate more careful evaluation of the effect of moisture, ash, and ash softening temperature on the true fuel value of competitive coals.

Test Engines for Diesel Fuel

(Continued from page 228)

mixtures of cetene and alphamethylnaphthalene (or suitably calibrated secondary reference fuels) it is possible to obtain cetene numbers which correlate well with those obtained by Boerlage and Broeze in spite of the wide difference in engines and operating conditions used. Figure 3 shows a sketch of the type of bouncing pin circuit used in this test.

The delay method of testing is not as rapid as the method employing the critical compression ratio but has been found to be somewhat more accurate. Grand average deviation in terms of cetene numbers, as a result of 25 tests, was found to be +0.8, the maximum variation being +2.2. This compares fairly satisfactorily with the octane number test of gasoline.

Cetene Numbers Available and Required

Diesel fuels from American crudes vary in general from about 75 cetene number, though there are a few isolated cases of higher cetene numbers, to as low as 33 cetene number; generally speaking, those crudes which give a high octane number gasoline, such as California or Gulf Coast Crudes, yield a low cetene number gas oil, and vice versa. Gas oils from cracked stocks vary from about 55 to 35. Certain special fuels, of course, may run higher or lower than the above figures; in particular aromatic extracts, as would be obtained by solvent extraction treatments of lubricating oils, may run as low as 20 cetene number.

A well designed high speed Diesel engine should be able to run smoothly at all loads and speeds with fuels of 40 to 45 cetene number, though many engines will be noticeably rough and noisy, particularly when running light and at low temperatures, on fuels of 60 to 65 cetene number. Many engines will, of course, run on fuels of lower than 40 cetene number, particularly the relatively slow speed central power plant engines which operate at constant speed and under relatively constant temperature conditions.

Mercury Vapor and Sodium Vapor Lamps Used Simultaneously

At the entrance to the River Works of the General Electric Company, at Lynn, Mass., there are being operated two new light sources, sodium vapor and high intensity mercury vapor lamps. In use simultaneously, the orange-yellow light of the sodium lamps blends with the greenish-white of the mercury lamps, producing an output of 175,500 lumens.

The display consists of 13 lighting units in seven locations along Western Avenue, on which the main entrance to the Works is located, and along the main avenue leading into the Works. There are six sodium vapor lamps, with three mounted on each of two standards immediately in front of the main office building. They are flanked by two standards, each of which supports two of the mercury vapor lamps. Three additional mercury units are mounted on standards along the main avenue of the Works.

The sodium vapor lamps are mounted vertically instead of in horizontal reflectors such as those used at Revere and Newton, Mass., and in other highway installations, and are within ornamental glassware which diffuses the light.

Each of the sodium vapor lamps consumes 235 watts and produces 10,000 lumens; each mercury vapor lamp uses 440 watts and has an output of 14,000 lumens, in addition to these, there are seven 2500-lumen Mazda lamps, one in each mercury luminaire for color correction. The entire installation therefore gives an output of 175,500 lumens and consumes 5.6 kw., giving an overall efficiency of approximately 31.3 lumens per watt.

Hardest Material Made From Borax

Boron Carbide developed at the Norton Laboratories is the Hardest material ever produced by Man.

THE HARDEST MATERIAL ever produced by man, closely approaching the diamond, was announced recently by Raymond R. Ridgway of the Research Laboratories of Norton Company, Worcester, Massachusetts, before the Electrochemical Society at Hotel Pennsylvania.

Together with grinding powders, moulded forms and drawing dies, he exhibited a beautiful gem, cut from the new material. Efforts to scratch this gem with other abrasive materials were unsuccessful, and it remained a beautiful example of an industrial black diamond, manufactured by man from simple raw materials from the earth with the aid of an intense application of electrical energy at temperatures and pressures exceeding those ever applied on an industrial scale.

This new material, chemically known as boron carbide, is a combination of the rare metal, boron and ordinary carbon, such as occurs in coke. The diamond is known as crystallized carbon, while the new product is a form of carbon crystallized with boron. Boron carbide is so hard that it readily scratches and cuts the hardest of known synthetic materials which have previously existed.

Boron carbide, which is unaffected by the strongest acids and alkalies, has compressive strength of 260,000 lb. per sq. in., coefficient of expansion approximately two-thirds that of steel, is little affected by temperature up to 1000 deg. C. at which point the diamond burns completely, and it is lighter than aluminum.

While the metal boron is rare in the metallic or crystalline form, it occurs throughout nature in large amounts in the form of minerals which contain it as an oxide, such minerals being familiarly known in the form of borax such as is used for washing purposes and in boric acid, used as a mild antiseptic and eye wash.

In the making of the new carbide, the purest medicinal quality of boric acid is taken from the hottest place in the United States, Death Valley. Into Searles Lake, which is so loaded with crystallizing solids that it has a crust as strong as a layer of ice, holes are drilled, and the saturated brine solution containing boron is pumped up from the lake bed. The extracted boron is shipped to Niagara Falls, where the high temperature electric furnaces, made possible by the great cataracts of the Niagara, convert it into an abrasive.

The first step in the process of conversion involves the removal of the water of crystallization which accompanies the boric acid crystals. The removal of this water changes the physical character of the smooth crystals into that of a hard glass slightly harder than ordinary window glass. This anhydrous oxide must be carefully protected to prevent it reabsorbing water from the air and returning to its normal form of boric acid. Carefully weighed quantities of the anhydrous glass are proportioned with the highest grade petroleum coke, since the inclusion of any ash impurities will destroy the quality and value of the resultant abrasive. In a furnace which reaches a temperature approximately 5000 deg. F. the oxygen is taken away from the glass and carbon substituted. At the very high temperature the carbide melts and from this melt crystallizes beautiful crystals of boron carbide which may serve as an abrasive just as they are taken from the furnace.

New Abrasive "Cuts" Tungsten Carbide

The new material has found an immediate use in the cutting and lapping of the new hard alloys known as cemented tungsten carbides which have replaced high grade tool steel in many industries. It was not long ago that these carbides were offered as a tool material of such great synthetic hardness that it was difficult to shape them with the ordinary abrasives. Metallurgists who have been baffled with the great hardness of these new tools of industry have been startled to see the ease with which they may be scratched and marked with the new synthetic abrasive which has been developed to use in this field.

Experiments have shown boron carbide to be useful for many previously unsuspected purposes. The art of pressure blasting has always been carried on in industry with the use of metal nozzles to control the spray of sand or other abrasive against castings and metal surfaces of all kinds. The cleaning of public buildings, the preparation of metal surfaces of automobiles before painting and the engraving of marble monuments has been carried out for years with the aid of pressure blasting or, as it is more commonly known, sandblasting. To a certain extent the application of hard abrasives to such cutting jobs has been impeded by the high rate of wear on the metal nozzle caused by the abrasive stream through it. The Research Laboratories of the Norton Company have found that this new carbide is very much harder than the hardest of the old abrasives and that it can be molded into pressure blast nozzles which show many thousand times the wear resistance under blasting conditions of any metal material previously used for this purpose. In some cases the purchase of one nozzle will last the life of a sandblast machine where formerly the nozzles used were completely destroyed in thirty minutes.

Because of the high intrinsic hardness of the product, its application to uses where gem materials have formerly been necessary, was immediately tried. In this field many successful uses have been uncovered. For the drawing of fine wires of all kinds it has for-

merly been economic to use large diamonds which have been carefully drilled to produce wire of a definite size by drawing through the opening metal bars a slightly larger size and reducing successfully the size of the metal rod until it is sometimes made so small that it is finer than the most delicate human hair. This application has been made of the new carbide and its use has been extended in this field. It has found application also for extruding dies, showing almost unbelievably long life with some materials.

Wear resistant bearings of all kinds have been manufactured of the new product suitable for inclusion in such widely different uses as electric meters and high speed rotating spindles on grinding machines. Here the high polish and hardness of the boron carbide approaches that obtainable with the highest grade process. The application of the boron carbide to the guide surfaces has solved this problem.

Thus a battle goes on similar to the race between the manufacturers of penetrating shells and high resistant armor plate. The advent of new materials of one type calls for the production of superior materials to control the new improvement of the other.

Engine Room Records

IN ALL PLANTS the engine room log is important and should never be neglected. These logs are usually made to meet local requirements or to comply with the needs or idiosyncrasies of various executives and department heads. Obviously some degree of uniformity is desir-

PLANT_____ DATE_____ 19__

TIME	STEAM PRESSURE	COND. PRESSURE (MACHINE NO. 1 2 3)	TEMPERATURE OF DISCHARGE GAS (MACHINE NO. 1 2 3)	RETURN PRESSURE (MACHINE NO. 1 2 3)	TEMPERATURE OF RETURN VAPOR (MACHINE NO. 1 2 3)	R P M (MACHINE NO. 1 2 3)	WATER TEMPERATURE: TO HEATER	TO BOILER	TO COOLING TOWER	FROM COOLING TOWER	TO CONDENSER	FROM CONDENSER	SUPPLY	FROM CONDENSER	FROM RECTIFIER	TO PRECOOLER	TO CANS	BRINE TEMP: TO STORAGE	FROM STORAGE	TEMPERATURE FREEZING TANKS (TANK NO. 1 2 3)	TEMPERATURE ROOMS (ROOM NO. 1 2 3 4 5 6)	TEMPERATURE ICE STORAGE	TEMPERATURE DAY STORAGE	DRAFT GAGE	DRY BULB TEMPERATURE	WET " "	BAROMETER	CO_2	STACK TEMPERATURE	VACUUM GAGE	SUPERHEAT DISCH. GAS	SUPERHEAT SUC. GAS
7 AM																															
10 AM																															
1 PM																															
4 PM																															
7 PM																															
10 AM																															
1 AM																															
4 AM																															
AVERAGE																															

MACHINE NUMBER	TIME: START	STOP	START	STOP	TOTAL
1					
2					
3					

ICE RECORD		
SHIFT	CAKES	TONS
FIRST		
SECOND		
THIRD		
TOTAL MFG.		
TOTAL SOLD		
SHRINKAGE		
BALANCE ON HAND		
TOTAL KW-HR. USED		
KW-HR. PER TON		
LB. COAL USED		
LB. COAL PER TON		
CU. FT. GAS PER TON		
GAL. OIL PER TON		

MAN HOURS	HOURS	RATE	TOTAL
ENGINEERS			
"			
"			
FIREMEN			
"			
"			
TANKMEN			
"			
"			
MISCEL.			
"			
"			
SPECIAL			
"			
"			
C. E.			
TOTAL			

METER READINGS	COMP. NO. 1	COMP. NO. 2	COMP. NO. 3	TANK AUX.	POWER AUX.	TOTALIZING	GAS	WATER	CIR. PUMP	OIL
PRES. RD.										
PREV. RD.										
DIFFERENCE										
K										
KW-HR.										

MATERIAL RECEIVED	MATERIAL USED	REMARKS—WEATHER
REFRIGERATION SOLD	REFRIGERATION PURCHASED	
		SIGNED 1ST SHIFT
		2ND SHIFT
		3RD SHIFT

Uniform Engine Room Log as Adopted by N.A.P.R.E. for Application to Steam, Oil Engine or Electric Refrigerating Plants

industrial diamonds. In a certain sense, therefore, boron carbide is a substantial attainment of industrial diamonds by synthetic means.

It thus appears that as soon as a need is developed in industry for a new product, the Research Laboratories set out to find it. The application of a new product of delustering rayon by the Research staff of the DuPont Company has led to great abrasive wear on the tiny thread guides which are used to control rayon threads on textile machinery. The ordinary porcelain and even synthetic ruby guides used on weaving and spinning machines have deteriorated so rapidly as to endanger the commercial feasibility of the able and such unification was undertaken by the Committee on Engine Room Records of the N.A.P.R.E. Under the chairmanship of I. J. Parrish, the log reproduced above was designed for universal application to refrigerating plants regardless of the type of drive.

ANNUAL REPORT of Westinghouse Elec. & Mfg. Co. for 1934 shows a net earned income of $189,562 as against a deficit for 1933 of $8,636,841. Sales increase was 39 per cent with better business in all principal divisions. Dividends of $3.50 a share were paid. The company expects to show substantial profit for 1935.

Case Studies in Power Economics

Conducted By
ZUCE KOGAN
Kogan Industrial Service
Chicago, Illinois

Metering of Demands of Multiple Load

IN PREVIOUS articles we have cited cases where the meter was unsuitable for the job or where the meter was generally incorrect. In this article we wish to describe a case where the meters were suitable for the portion of power they measured but the method of totaling the readings of the meters meant a considerable loss to the plant.

Normally the cost of purchased power in industries is determined by a demand charge and energy charge. The demand charge is in reality a "readiness-to-serve" charge and is based usually on a short time interval, usually about 30 min., and it is defined as the maximum power used during this short interval in any month. The energy charge, as the name implies, is a commodity charge and its cost varies on a sliding scale.

Furthermore, it is usually the case that light and power be purchased on separate circuits. Power on a 220 v. or 440 v. circuit and lights on 110 v. circuit. Each portion of the purchased power, that is power proper and the lights, is metered both as to demand and energy on separate meters. The meters used in the smaller sized plants are of the integrated indicating type. This is a type of meter where a needle indicates the maximum amount of power used in a given half hour in the month and the needle is so arranged that it will only move forward, that is, it will indicate a higher demand if one is established, but it will never move back and it can only be reset by the meter man of the power and light utility.

In this type of meter only an indication of the maximum demand is shown but the time when such demand was established is not indicated. Thus when two meters of this type, one indicating the demand on lights and the other indicating the demand of power are used, the time at which each individual demand was established is not known and they may be at various intervals of time. By proper knowledge of the exact time when such demand is established and by coördinating these demands considerable saving in the purchase of power can be obtained.

Such a condition existed in the plant of one of our clients. This client was the manufacturer of automobile accessories and besides had an automobile service station. The power and light were measured separately both as to demand and energy. The light demand was on the order of about 30 kw. and the power was about 80 kw. This plant was well lighted and consequently little artificial light was used during the daytime with the exception of a few dark corners and in the office. On the lighting circuit were connected several small office equipment devices. The working day normally ended about 4:30. At about 4:45 p.m. in winter and 8:00 p.m. in summer the entire front of the building would be illuminated; besides, several large neon and lamp signs were turned on and this constituted a demand of about 30 kw. This means that a demand on power was established sometime during the day and the demand on light was established sometime after 4:30 p.m., that is after the work was ended. When the utility meter man came to read the meter, however, he found the maximum demand on the light to be about 30 kw. and the power demand to be about 80 kw. or a total of about 110 kw. The demand charge on this power and light at the rate of $2.00 per kw. was $220.00 per month.

We were called in by the owner of this company to survey his plant, especially his heat treating furnaces and boilers. Since there were some small electric furnaces we had an occasion to read the electric bills. In studying the bills we noticed the effect of the meters. We pointed out to our client the condition and recommended that the type of meters be changed to a recording type, or that a transformer be installed so that both power and light be metered through one meter. Since the cost of a transformer entailed a comparatively higher expenditure than the rental of meter, our client decided for the time being to rent the meter at $4.00 per month.

After the recording type meters were installed his demand was immediately dropped to 85 kw. and the reason for this was the following:

His maximum power demand was normally established around 11:00 a.m. According to the type of operation, this was his heaviest hour as practically all of the machinery was going at that time in order to have shipments ready about 3:00 p.m. The light, as we mentioned previously, was normally low as his plant was well illuminated by natural light in most places. The actual amount of light used during the day was equivalent to about 5 kw.

In this type of recording demand meter the half hourly demands were recorded on a tape and the time at which demand was established was indicated alongside of it. The electric power utility removes the tape of the two meters and from these two tapes determines the maximum demand, which is the highest sum of the light and power demand at any given half hour. That meant that sometimes during the day our client had about 80 kw. on power and about 5 kw. on lights. Towards evening, at 5 o'clock or later he had 30 kw. on lights due to the illumination of the front of the service station and the sign plus about 6 or 7 kw. for equipment operating the plant, such as, in the winter-

time, stokers and pumps, or a total of 37 kw. Since the day demand was the largest, most naturally this demand was billed on.

Hence, by changing the type of meter to a recording type our client was able to reduce his demand by 25 kw., that is, from an average of 110 kw. to an average of 85 kw. This 25 kw. represented $50.00 a month or $600.00 per year. The expenditure involved for the rental of the meter amounted to about $50.00 per year, hence there was a net saving of about $550.00. The saving was increased when he purchased a transformer and metered the power and light on one meter. The transformer was obtained for about $180.00 so after the first four months the full saving of $600.00 per year was enjoyed by our client.

Coal Classification

AFTER careful consideration of the combination of qualities of coal available, the variety of plant characteristics, and the interrelation of these factors, the Joint Committee on Fuel Values of the A. S. M. E. and the A. I. M. E. is convinced that it is impossible to set up any scale of values, or to devise any formula for general application that will accurately reflect the values of different coals for steam generation.

A list of some of the factors to be considered is sufficient to reveal the impossibility of assigning definite values to any one or combination of coal qualities. Coals that are alike in all other respects may be evaluated according to their B.t.u. value, but when they differ in any important physical characteristic the relative B.t.u. value must be modified according to the effect of those differences on the performance of individual plants.

While many considerations have led this Committee to the conclusion, already stated, that no definite values can be assigned to individual coal qualities for steam-generating purposes, the Committee is of the opinion that there is an opportunity for much constructive work in the collection, organization and interpretation of *experience* data, which will assist the individual consumer to establish his own scale of values to suit his particular circumstances, and be helpful to the coal industry in the preparation of coal to meet a wide variety of consumer requirements.

The Committee will study, on the basis of practical operating experience, the relation of individual coal qualities to the plant conditions which they affect in order to establish, where possible, the limits within which, under certain conditions, specific coal qualities may affect efficiency, operating costs, and capacity; and to suggest methods by which the individual consumer can arrive at his own scale of values.

Some of the factors that should be considered, and to which additions may be made as the work progresses, are given below.

I. Physical and Chemical Properties.
1. British thermal units (as shipped and as fired).
2. Moisture per cent.
3. Ash per cent.
4. Sulfur per cent.
5. Volatile per cent.
6. Hydrogen.
7. Fusing temperature of the ash.
8. Size.
9. Grindability.
10. Friability.
11. Coking characteristics.
12. Chemical composition of ash.
13. Character of clinker formation.
14. Ignition rate.
15. Uniformity or variability of one or more of above qualities.

II. Plant Characteristics
a. According to type of coal-burning equipment:
1. Hand-fired.
2. Stoker-fired.
3. Pulverized coal.

There are numerous variations in detail in the equipment available, under each of these broad classifications, and in addition, any two plants, though identical in coal-burning equipment, may vary in one or more of the following:

b. 1. Size and/or shape of furnace.
2. Amount and kind of water-cooling surface in the furnace.
3. Available draft.
4. Amount of heating surface exposed to radiant heat.
5. Maximum load.
6. Duration of maximum load.
7. Character of load.
8. Coal handling and storage facilities and requirements.
9. Spare units available.
10. Competence and adaptability of boiler-room personnel.

The variables above, (b), will affect furnace or fuel bed conditions, by determining:

1. Rate of fuel feed.
2. Temperature of fuel bed.
3. Temperature of furnace.
4. Length of flame travel.
5. Heat release. (B.t.u. per cu. ft. furnace volume per hour).

Depending upon the particular combination of these factors in a given plant, coal qualities may limit (a) efficiency, (b) operating cost, and (c) capacity, as follows:

III. Efficiency
a. Coal qualities may limit the efficiency of a given plant by their effect on:
1. Loss of unburned solid fuel in the ashpit, or carried off through the boiler.
2. Distribution of air in the fuel bed, directly affecting the percentage of carbon monoxide and carbon dioxide in the flue gases.
3. Loss due to hydrogen and moisture.
4. Loss by fouling of heating surfaces.

b. Operating cost.
The effect of coal qualities on operating cost will vary among plants, according to:
1. Method and cost of coal and ash handling, including maintenance of coal and ash-handling equipment.
2. Labor wage scale, and relative amount of labor required per unit of steam output.
3. Maintenance of:
a. Grates.
b. Furnace.
c. Pulverizers and burners.
d. Fans.

c. Capacity.
Coal qualities may affect the capacity of the plant by their variation in:
1. Clinkering.
2. Character of the fuel bed.
3. Rate of ignition.
4. Grindability.
5. Fouling of heating surfaces.
6. Any efficiency limitation, or deficiency in B.t.u., that requires the handling or preparation of quantities of coal and/or ash in excess of the capacity of handling equipment.

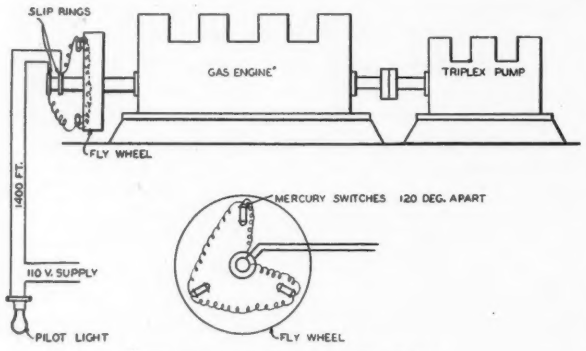
UNAFLOW VERTICAL engines of 1600 hp. at 200 r.p.m., built by the Skinner Engine Co., are in use on the ferry steamer Delmarva in Chesapeake Bay. They are of 4-cylinder type with nickel-iron cylinders 19 by 20 in. running with 300-lb. steam superheated to 650 deg. F. Use of dense, close grained metal permitted casting the poppet valve seats integral with cylinder heads and grinding of admission valves while cold to fit, steam tightness being maintained at full operating pressure and temperature. Steam rate is reported as 10.15 lb. per hp.-hr. and oil consumption as 1 gal. per 15,000 hp.-hr.

Readers' Conference

Positive Indicator Showing Engine Operation

A MID-WESTERN mine uses a gas engine to pump out the water which seeps into the lower levels. This engine usually operates 20 hr. a day but as it is located about 1400 ft. from the night watchman's headquarters, he cannot hear the exhaust when the wind is in a certain direction. Normally the plant engineer visits the pump room twice daily but the night watchman is required to look after the pump and engine during the night.

The device shown in the sketch was installed in order that the night man could be sure the engine was in operation. In case it stopped, the pilot light would be extinguished. Three mercury switches were installed on the flywheel of the engine and were 120 deg. apart so, regardless of the position at which the flywheel came to rest, the circuit was broken. When the engine is in operation, centrifugal force throws the mercury into the outer end of the mercury switches where the two leads enter the glass tube. As the three



Mercury switches for pilot light

switches are wired in series, centrifugal force is the only means of closing the circuit. In case the light goes out in the watchman's headquarters, he knows at once that the engine has stopped and can then take steps to remedy the difficulty.

South Bend, Ind. CHAS. A. PETERSON.

Carrying Charges

WHEN CONSIDERING the advisability of installing a power plant or other mechanical equipment, it is a quite common practice to over estimate the carrying charges on the investment, as the following example will indicate.

Let us assume that we are dealing with the problem of deciding whether it would be more advantageous to install a power plant or to purchase power from a public utility company. The usual procedure is somewhat as follows.

Estimated investment	$50,000.00
Anticipated life	20 yr.

Scrap value.—None assumed for sake of simplicity.

On this basis the plant would depreciate $50,000.00 in 20 yr., which would be at the rate of $2500.00 a year. We should therefore charge off $2500.00 a year for depreciation which amount may be invested in securities, or left in the business if that appears to be more profitable. In any event it should no longer remain as a charge against the power plant, but the mistake that is too often made is in assuming that the power plant should be charged interest on it, for instance, as follows.

Interest on $50,000.00 at 6 per cent	$3000.00
Depreciation	2500.00
Annual charge, interest and depreciation	$5500.00

This represents an annual charge of 11 per cent on the original investment.

Now with an investment in the plant of $50,000.00 at the beginning and nothing at the end of the 20 yr. period, the average investment is $50,000.00 ÷ 2 or $25,000.00 on which interest should be charged, which gives the following average yearly cost.

Interest on $25,000.00 at 6 per cent	$1500.00
Depreciation	2500.00
Annual charge, interest and depreciation	$4000.00

which is 8 per cent on the original investment, or 3 per cent better than the charge indicated by the faulty method of estimating often employed.

These facts are well understood by professional accountants who, owing to the fact that it is the practice to make depreciation charges annually instead of daily, use the following formula which gives a slightly higher total charge based upon 6 per cent.

$$\frac{M+1}{M} \times \frac{(\text{Investment} \times 0.06)}{2}$$ in which M is the assumed life of the plant.

The application of this formula to our problem would make the average yearly interest charge 3.15 per cent on the original investment of $50,000 instead of 3 per cent.

At this time, when so much consideration is being given to the question of generating instead of purchasing power, it is very important that the above principles should be well understood, as an error of 3 per cent or even 2.859 in estimating charges on the original investment may prove to be the governing factor in arriving at a wrong decision.

It should of course be kept in mind that at the end of 20 yr., the plant would still have some value, if only for scrap, and a reasonable allowance should be made for this.

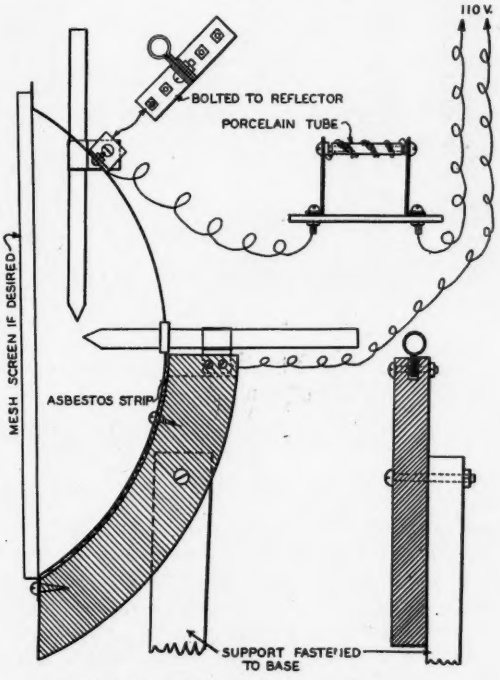
Bloomfield, N. J. JAMES O. G. GIBBONS

Building a Handy Searchlight

OCCASIONALLY there arises a need for some sort of powerful light around the shop. The one herein described can be quickly assembled from odds and ends. Once constructed it can also serve for melting metals or for ultra-violet ray treatments.

To begin I bought an old auto headlight reflector from a junk shop for 10 cents, begged two carbon pencils from the local movie theater, and also picked up an old electric stove or toaster element at the electric light office.[1] The reflector should be in good condition so far as its silvering is concerned, and the electric stove element should be the open coil type.

A slot cut in the reflector allows one carbon to enter from the top and since it is held in a clamp



Details of home made arc lamp

which is pivoted, the carbon's point may be moved in our out to change the lamp's focus. The second carbon enters from the back through the hole which originally held the lamp bulb, this hole being large enough to allow the carbon to be mounted without touching the reflector. It must not touch the reflector because a short circuit would result since the top carbon is mounted in direct contact with the reflector.

A detail sketch shows how the two carbons are actually held solidly in place. A board was sawed out with a scroll saw so that it exactly fit the curve of the reflector. This, then, is fastened on with wood screws and serves as a means of mounting the lamp on the stand and also furnishes a mounting for the rear carbon as will be seen from the sketches. Any kind of a stand will be suitable; a bolt serves to hold the lamp in place and allows it to be tilted up and down.

[1]Such elements can also be purchased for 10 or 15 cents at Woolworth's or Kresge's stores.—Ed.

With the lamp mounted on the stand all that remains to be done is the wiring. Two wires connecting to the carbons are led down to the base. One of these wires goes to the 110 v. attachment plug, the other to one side of the stove element. The other side of the element is connected to the 110 v. attachment plug. The element gets red hot when the lamp is in operation so care must be taken to mount it far enough away from all wood parts so that the wood will not be scorched. A porcelain tube may be used to wind the stove element on. As the sketches show, two pieces of brass with bolts too short to touch inside the tube serve as a mounting for the porcelain tube. The ends of the element are held by the bolts at each end.

Some experimenting may be necessary in determining the amount of the element to use. If you have a whole one (designed to operate on 110 v.) to start with, use about half of it on the lamp. The amount used will govern the current drawn from the line and this in turn will govern the strength and heat of the arc. The less resistance wire (element) used, the easier the arc will start. However, don't try it with too small an amount of resistance in series, otherwise out will go your house fuses.

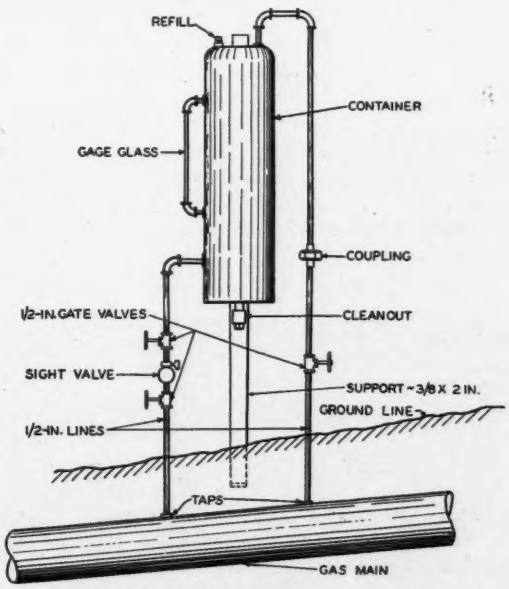
To start the lamp, of course, simply touch the carbons together, then separate them. By adjusting the carbons, the position of the arc, with reference to the reflector, can be changed; the rays can thus be concentrated or spread as it is desired.

For safety a large-mesh screen may be placed over the face of the lamp and over the resistance coil (element). *Always wear goggles with dark glass when using the lamp.* Overexposure to the rays may cause blindness.

La Crosse, Wis. VERNON W. PALEN.

Feeder for Gas Odorizer

WE HAVE 5 mi. of gas lines, running underground about the college campus, piping natural gas to all the buildings and campus residences. Ordinarily there is no way to ferret out leaks on these lines



Adjustable odorizing device for natural gas

unless a special detector costing $150 is used. These special detectors are of no use in the house around stoves, heaters, or at the connections of any natural gas appliance.

It was deemed expedient for us to devise a means of detecting minor leaks near and about the service and houses in the small connections where the minute leaks were not so easily detectable.

I designed the home-made odorizer described here at the cost of $27 installed. We used ½-in. wrought-iron piping, five ½-in. ells, three ½-in. gate valves, 1 coupling, a special sight valve, an old discarded water tank of about 2 gal. capacity, a strip of ½ by 2-in. iron for the support, two different sized plugs for cleanout and refill, respectively, and a piece of glass. All of the connections to the container were welded. The gage glass was made with the ells and the glass and a sealing material. All screwed connections were sealed with prepared lead. Two taps were made to the gas main with a regular tapping machine. A substance bearing the trade name "Pentalarm" was purchased at the price of $1.35 per lb. It is an organic compound of distinct and easily detectable odor suggesting gas. It was mixed with gasoline to deliver a charge of a maximum quantity of one pound per million cubic feet of gas.

Since the installation of this equipment which cost far less than the manufactured setup, many leaks have been detected and repaired and our gas bills have been reduced many times the cost of the unit installed. The equipment has paid for itself many times over and in addition it has served to reduce the maintenance costs of our gas lines.

Tuskegee Institute, Ala. E. G. ROBERTS.

A Home-Made Wood Turning Lathe

IN MANY SMALL plants where a small lathe is needed occasionally, the home-made affair described here may prove useful. It was made during odd times from material around the plant at little cost.

A table 3 ft. high, the frame of which was made of two by fours, was the first step. Size is immaterial since the reader may wish a larger or smaller one. The length of the table, of course, limits the length of the work that can be turned.

A rectangle of two by fours to which the legs are bolted gives a solid frame. A shelf added below furnishes added strength and a convenient place to store turning stock.

One-inch boards nailed on the top of the frame form the working surface or bed of the lathe. A ¼ hp. motor is mounted on the top of the extreme left end of the table. It may be well to mount the motor on a 2-in. block so as to raise the shaft higher and allow for turning stock of larger diameter.

A slot 1 in. wide and extending from the motor base to the other extreme end of the table is cut through the center. This serves as a guide and means of mounting the tail stock.

The tail stock consists of a piece of two by four cut as shown to fit the slot. A hole drilled up from the bottom and a nut inserted in a slot in this member allows a bolt (with washer) to hold the tail stock

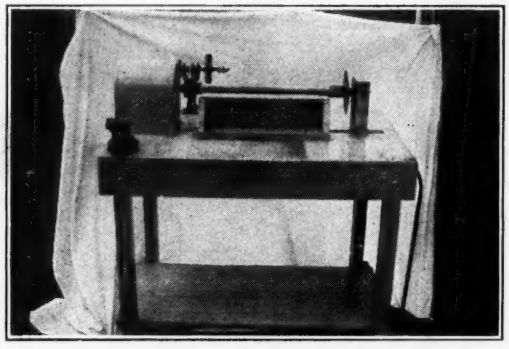


Fig. 2. Simple wood turning lathe

firmly in position. Incidentally, the writer used one of the pressure adjustment hand wheels off an old clothes wringer for this purpose instead of an ordinary bolt, thereby making it unnecessary to use a wrench in making the adjustment. A hole drilled horizontally through this tail stock and used in the manner to be described later furnishes the support for the free end of the work being turned.

Two circular pieces of No. 20 gage sheet metal shown in the sketch were cut. One of these is bolted directly to the motor pulley. The other disc is mounted on a threaded shaft, the threaded end of which protrudes through the disc and is ground to a sharp point. This shaft passes through a bushing in the wood tail piece and a cotter pin keeps the assembly together. The slots in the discs serve as a means of mounting and adjusting small angle brackets which hold the work. On the motor end these angle brackets also transmit the power. This method of mounting the work relieves the strain and prevents splitting out when turning pieces of small

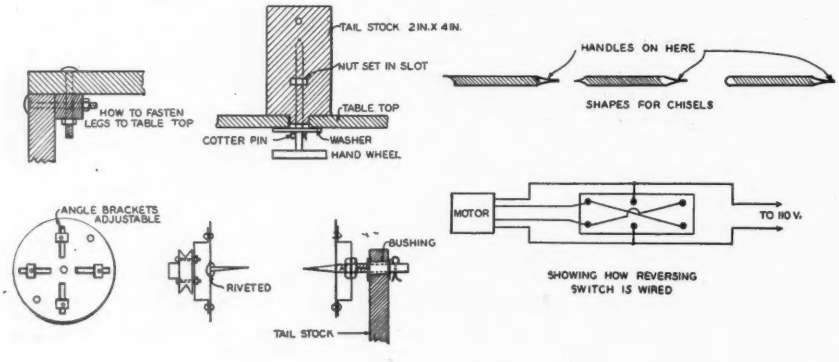


Fig. 1. Details of home-made lathe

diameter. This often happens with the conventional method of mounting since in making a cut the pressure must be borne entirely by the tail stock spindle about which the work revolves. On the writer's lathe the tail stock spindle revolves within the work.

Any kind of tool rest may be designed but the writer simply uses a board stood on edge and held to the table top by means of small shelf brackets.

Chisels for cutting are fashioned out of old files. Different shapes and angles will suggest themselves to the reader as he becomes familiar with turning.

The writer mounted a reversing switch beneath the table top so that the motor rotation might be changed. This was done in order that the motor could also serve to operate an emery wheel (seen in the photo) mounted at the back of the table. The reversing switch consists simply of a two-pole double throw switch and wired as shown in the diagram.

The writer has had a lot of pleasure and satisfaction from this homemade machine, and has turned out some surprisingly good work. Allowing $3.00 for purchase of a second-hand washing machine motor, at most the assembly should be duplicated easily for $5.00.

La Crosse, Wis. VERNON W. PALEN.

Drive Problems

IN MANY CASES where substitutions are made, say from a direct current motor drive to alternating current, the problem comes up whether it is more economical to substitute speed for speed and drive for drive or to go ahead and redesign and install a totally new drive. Usually it works out into a question of efficiency and cost. If the motor is driving some very important machine for 24 hr. a day, the question of efficiency is foremost and in all probability the selected drive would be new and not so much attention should be given the investment.

For a specific problem I have in mind a grain elevator drive for which alternating current was to be substituted for direct current. The former drive was a 590 r.p.m., 25 hp., 220 v. direct current motor. The power was to be changed over to 440 v., 3 phase 60 cycle. The drive was a silent chain having a ratio of 4 to 1, in good condition, and capable of many years of reliable service. This elevator was operated from one to six hours a day and intermittently. The question of efficiency was not the paramount consideration. An alternating current motor with a full load speed of 575 r.p.m. could be substituted without making any changes in the drive or position of the motor. This slight decrease in speed had no great effect on the capacity of the elevator. The objection to a slow speed 600 r.p.m. synchronous speed motor is the cost which is considerably above that of say a 1200 or 1800 r.p.m. motor. The power factor of the slower speed motor is also lower than the high speed motors. The highest speed motor which could be used with the jack shaft would be a 900 r.p.m. motor with a 6 to 1 V-belt drive. The difference in cost between a 600 and 900 r.p.m. motor would not be enough to take care of the new drive and pulleys which would have to be purchased. If it were possible to go to 1200 or 1800 r.p.m. the cost of the motor would be reduced so that a new drive could be substituted. Here, however, it would require the use of another jack shaft and it is doubtful if there would be any saving, besides taking up a great deal more space. What was finally done was to purchase a used a.c. motor in good condition having a full load speed of about 575 r.p.m. at a cost slightly less than a new high speed motor. The old pinion was fitted to the shaft and the original drive left intact. This method worked out several hundred dollars cheaper. It does not always happen that a used motor of the correct speed can be obtained. When such is the case it would probably work out that a gear reduction would be used. Here a high speed motor can be used with better operating efficiency and practically dustproof. These gear reductions can be obtained in almost any ratio and any terminal speed desired.

When a new elevator was installed a new gear motor of 7½ hp. was chosen. The speed of the head pulley was 44 r.p.m. Here no question was brought up about what type of drive should be used. It saved the cost of jack shafts and pulleys and bearings. Using the same speed motor, 1750 r.p.m., which means a reduction of about 40 to 1, at least two jack shafts and possibly a gear reduction to boot would have to be used. On account of space requirements this would have been very impractical. A slower speed motor would have to be used and an increase in cost would result. All in all, the gear reduction unit was found to be the most economical unit to install.

In other cases where the speed of the driving motor is 1000 r.p.m. or better it is possible by changing the motor pulley slightly to conform to the given countershaft speed, to substitute direct drive for drive.

Waterloo, Wis. K. B. HUMPHREY.

Guards from Wire Cloth

IN CASES where it is desirable or necessary to enclose moving machinery parts, pulleys, shafting, or motors, it is always best to leave the guarded part or parts visible as far as possible, even while protecting them as fully as possible. Further, in the case of a motor that is to be guarded, it is necessary to provide for sufficient ventilation so that the motor can continually free itself of the heat it generates in running. For these purposes, while sheet metal, and sometimes special perforated sheet is used, a heavy grade of wire cloth is in most cases better. It allows a free flow of air to a motor, and it allows good visibility of most any part which it is used to protect.

In building guards of wire cloth, it is necessary to make up a light framing over which it may be stretched. The framing may be of light bar iron or of angle iron. A splendid method is to make each surface of the guard of two such lightly framed units, sandwiching the wire cloth in between them, and drilling and riveting through the two frames to retain the wire. This absolutely eliminates all rough edges, and makes a first class guard in every respect. In dusty places, such guards may be blown out periodically with a portable blower, to keep them clean and functioning in proper order.

Peoria, Ill. JOHN E. HYLER.

New Equipment

Welded Penstock for T. V. A.

RECENTLY, Chicago Bridge and Iron Works completed, for the Norris Dam of Tennessee Valley Authority, two steel penstocks 20 ft. diam. with thickness 1⅛ to 1⅜ in., using the Electronic Tornado system for the parts automatically welded. This system employs a magnetically controlled carbon arc which with the proper flux gives welds to meet A.S.M.E. Class 1 welding specifications.

Plates were formed into semi-cylindrical sections 10 ft. long at the Birmingham plant, then shipped to the field fabricating plant, Fig. 1, 25 miles Northwest of Knoxville, where four plates were welded together to form a section 20 ft. long by 20 ft. diam.

In the welding, two plates were tack welded in a special form to make a cylindrical section, then the seams automatically welded. Two 10-ft. sections were then tack welded on a circumferential joint, placed on power-driven rolls and the joint automatically welded, all welds being of double U type. For stiffening, a steel ring 1 7/16 by 8 in. was welded around each 10-ft. section as shown in Fig. 2.

Seams were X-rayed, any defects disclosed were repaired and joints were stress relieved by heating welds electrically to proper temperature, then allowing to cool slowly with heating elements and insulating blankets in place as shown at the right in Fig. 2. Tests were made by cutting samples from test plates welded under identical conditions, the specifications calling for tensile strength of 55,000 lb. per sq. in.; 20 per cent elongation in 2 in.; specific gravity, 7.80; free 180-deg. bend with 30 per cent elongation in outside fibers, with no indication of fracture or tear.

After inspection and approval, the 20-ft. section was hauled to the dam, swung on a cableways and lowered into position on cradles, Fig. 3, the sections being then welded together by the manual shielded arc process. All welding was done by Chicago Bridge and Iron Works operators, under the direction of O. A. Bailey, chief engineer, using equipment and material supplied by The Lincoln Electric Co. of Cleveland, Ohio.

Barton M. Jones, construction engineer on the Norris Dam stated: "I was much pleased with the speed at which welding was done, since it had to meet our stringent requirements in all details."

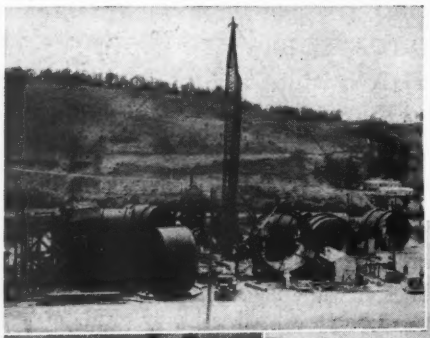


Fig. 1. Field fabricating site near Norris Dam. At left.

Fig. 2. Completed 20-ft. sections and method of relieving stress in joints. Below.

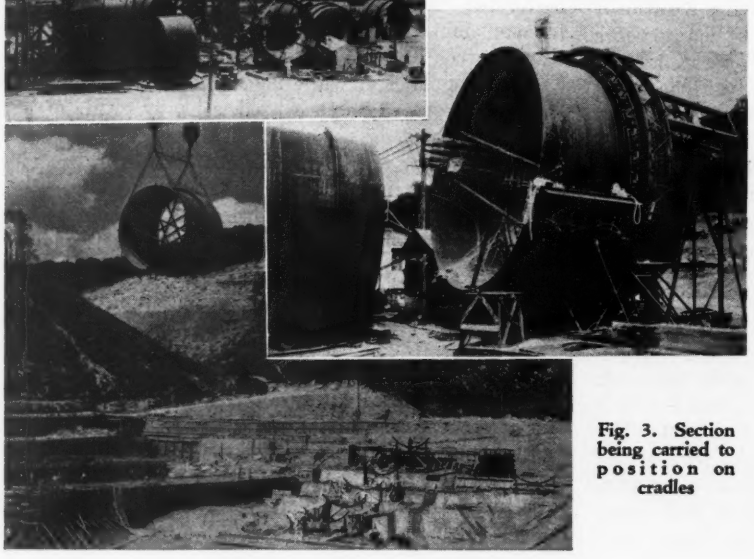


Fig. 3. Section being carried to position on cradles

New Ground Detector Relay

A NEW GROUND DETECTOR RELAY —to promote continuity of service, reduce circuit breaker operation, protect line equipment from damage resulting from arcing grounds, and to help prevent telephone interference that might result from a grounded line—has been announced by the General Electric Co. This relay, which may be used to trip a breaker or to give a signal to indicate a ground, is a relatively inexpensive equipment that may be installed in any station where delta-Y connected power or potential transformers are located.

The equipment consists of a coupler unit and a relay unit. The relay unit consists of a potential relay (with a single set of circuit-closing contacts), a condenser and a resistor, mounted in a standard universal case, 5½ by 6 in. This relay unit is operated from a Thyratron tube which in turn is operated from a Thyrite coupler connected directly across one phase of the three-phase ungrounded high-voltage line.

The Thyrite resistors, linear resistors and the Thyratron tube which make up the coupler unit are assembled within an oil-filled metal tank fitted with porcelain bushings for direct connection to the line. Where the conditions are convenient, the cost of the tank and bushings may be saved by mounting the coupler elements inside the tank of some piece of apparatus, such as a transformer. The relay unit is usually mounted on the switchboard.

New Type Monel Metal

ENGINEERS of The International Nickel Co., 67 Wall St., New York City, have produced a new type of Monel Metal which combines the strength of alloy steels with the

corrosion resistance of regular Monel Metal.

This new alloy, known as K Monel, is practically the same in analysis as regular Monel Metal with the exception of about 4 per cent added aluminum and fractional amounts of other elements. It is readily heat treated and its fully hardened condition shows Brinell values above 350, though it is available also in softer forms. Its tensile strength runs higher than 160,000 lb. per sq. in.

New Lunkenheimer Air Nozzles

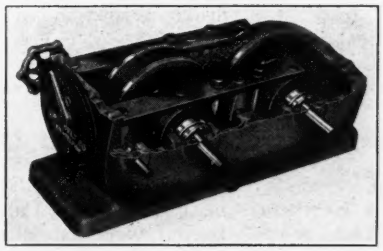
TWO NEW DESIGNS of bronze air nozzles, with renewable, non-metallic discs, have been placed on the market by The Lunkenheimer Co., Cincinnati, O. One is made with integral hose end, and the other with female pipe end. Either pattern can be furnished with pointed, flat, or extension tip.

These Air Nozzles find wide application for blowing dust, dirt, chips, filings, borings, sand, lint, liquid deposits and other matter, and quickly pay for their initial cost in savings of time and labor, and prevention of air wastage. They are more effective and safer to use than brushes, rags and hand bellows.

The disc is especially compounded for air service, and easy renewability insures seat tightness. To renew a disc, simply unscrew the nut at bottom of nozzle and remove spring and old disc; insert a new disc and reassemble.

Link-Belt V.R.D. Gear

ONE OF the recently developed products of Link-Belt Co., 300 W. Pershing Road, Chicago, Ill., is the V. R. D. (variable roller drive) a mechanical speed selector with which it is possible to secure an infinite number of speeds easily and quickly while the machine is in operation. The characteristic feature of this drive is the design of the chain which is made up of links with rollers at each side that contact the conical steel driver and driven disks. These rollers have their axes parallel with the length of the link so that they offer little resistance when moving in a radial direction across the disk but set up great friction when movement is attempted circumferentially around the face of the disk.



The operating mechanism is built into and totally protected by a compact oil-tight housing, and is automatically splash lubricated. Embodied in the design is a simple device for maintaining correct tension and compensating for natural chain wear automatically which is accomplished through the action of two helicoid springs. Speed changing mechanism may be provided for either manual, automatic or electrical automatic remote control. Friction loss is reduced to a minimum by the use of ball and roller bearings. At present only the ½-hp. size is available with a maximum ratio of speed variation of 10 to 1, this unit, however, is a companion to the P. I. V. gear which is obtainable in capacities from 1 to 10 hp.

Super Silvertop Trap

DESIGNED for economy in installation, and convenience of inspection and cleaning, as well as for removing condensate from steam lines without loss of steam, the new Super Silvertop trap placed on the market by the V. D. Anderson Co., 1935 W. 96th St., Cleveland, O., has many unique and exclusive features.

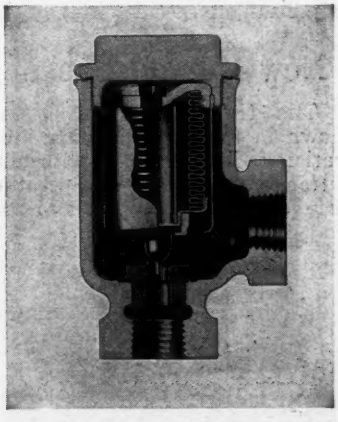
In principle, the trap is of the inverted bucket type in the form of an annular ring surrounding and guided by a hexagonal intake tube whose edges reduce friction yet keep all parts of the trap in alignment. Of particular interest is the extreme simplicity with which the trap is installed in the drip pipe line. Piping is screwed directly into the head of the trap, without additional fittings, with an alternate choice between side and top entrance for the inlet connection.

For internal cleaning and inspection, the body of the trap may be removed simply by opening a flanged joint and without disturbing pipe connections. Accumulation of sediment and sludge that may collect at the bottom of the trap can be removed by unscrewing a blowdown plug.

Working parts are of heat-treated stainless steel and valve and seat of Anderloy, a special chrome alloy developed to resist the erosive action of steam and water. These traps are built for operating pressures ranging from 1 to 250 lb. and capacities from 200 to 9600 lb. of water per hour.

Sarco Steam Trap

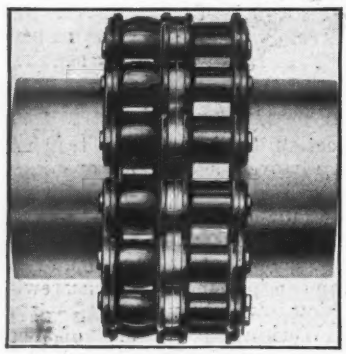
FOR INDIVIDUAL trapping, a new design has been added to the series of traps manufactured by Sarco Co., 183 Madison Ave., New York City, especially suited to drain high pressure steam coils and



jackets in connection with industrial heating and process work. It can be used for any steam pressure, steady or fluctuating, from 0 to 200 lb. per sq. in. It requires no adjustment in the field when steam pressure changes. The thermostatic bellows is made from helically corrugated tubing with special caps screwed onto the top and bottom of the bellows.

Baldwin-Duckworth Flexible Coupling

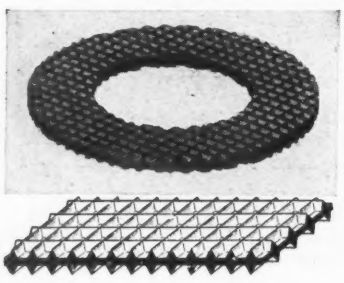
To PROVIDE for free operation without friction and excessive noise, which is accomplished by the use of special double width roller



chains, Baldwin-Duckworth Corp., Springfield, Mass., has placed a new design of flexible chain coupling on the market. One strand of the chain is equipped with the standard cylindrical rollers whereas the other strand has convex surface, oversize rollers which provide for free operations where shaft deflection and misalignment exist. Permanent shaft deflections up to three degrees can be handled without undue strains, thus taking care of shaft joint with wabbles or permanent eccentricities.

New Metallic Gasket

THE NEW MULTISEAL GASKET shown in the accompanying illustration is designed to withstand extreme pressure, temperature change and vibration, and to produce perfect tightness with only 30 per cent as much contact surface as on a plain flat metal gasket, and consequently with greatly reduced bolt pressure. This is accomplished by providing the faces with crossed ductile and resilient raised ribs, which under very small bolt pressure, are said to set themselves into tight contact even on imperfect flange faces.



They are available as solid copper, steel, armco iron, aluminum or lead, or as a metal shell with asbestos filler, and in any circular, elliptical or special shape. Multiseal Gaskets are made by Goetze Gasket & Packing Co., New Brunswick, N. J.

Control for Boilers

METERMAX UNIT COMBUSTION CONTROL is announced by the Leeds & Northrup Co., Philadelphia, Pa. This control is built, assembled, and tested at the factory and shipped as a unit, ready for installation. First cost is greatly reduced and installation costs are cut to a fraction of former figures by this method of construction.

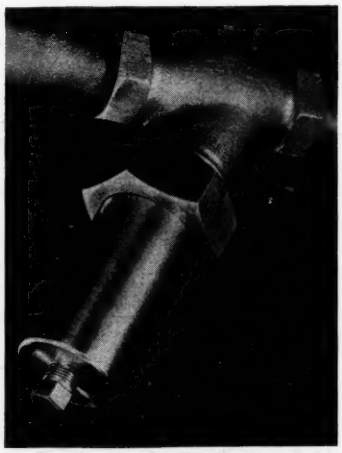
It is an improved development of the well-known, widely used L&N Metered Combustion Control.

It maintains an air loading pressure in definite relation to steam demand and balances against this pressure metered supplies of fuel and air to each boiler. It employs electricity as the power medium.

There are four controllers of primary simplicity, ready-mounted and connected on a panel. The master controller connects to all boilers and balances steam pressure against an air loading pressure. The fuel-feed controller, air-flow controller and furnace pressure controller at each boiler are simple mechanical balances with but one moving element, and each has integral push-buttons built into the case.

Forged Steel Strainer

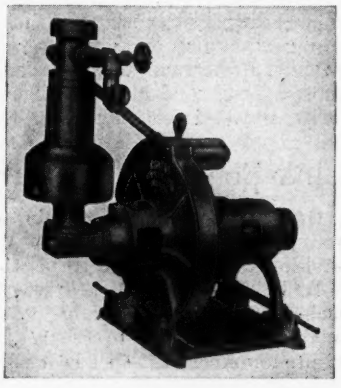
THE EDWARD VALVE & MFG. CO., Inc., East Chicago, Indiana, has placed on the market a line of forged steel strainers especially



designed for high pressure-temperature service but available for the lower pressures and temperatures as well. The bodies are of selected forging quality steel, heat treated and machined with full, properly aligned threaded pipe ends. The standard removable strainers are of perforated Monel metal. In addition to the cap for removal of the screen for cleansing purposes, a threaded pipe plug is provided through which accumulated foreign matter may be blown out. Screen dimensions are proportioned to give an effective flow area through the perforations equivalent to about seven times the pipe area.

New Steam Turbine

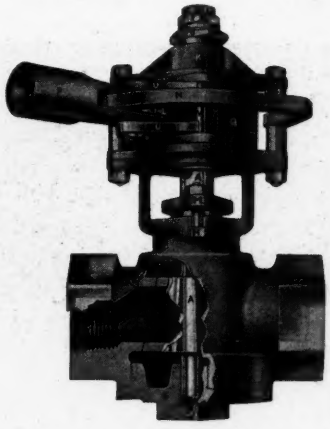
PROVIDING A POWER UNIT for services requiring up to 3½ hp.,



a new steam turbine known as the Trojan Turbine has been developed by the California Bettis Co., Los Angeles, Cal. The machine is built complete with a base plate on which can be direct-connected the generator or a pump of any standard design. The weight, complete, is approximately 275 pounds.

Golden-Anderson Thru-Flow Valve

FOR STEAM, air, gas and any liquid fluid service lines, the lever operated Thru-Flow valve developed by the Golden-Anderson Valve Specialty Co., Fulton Bldg.,



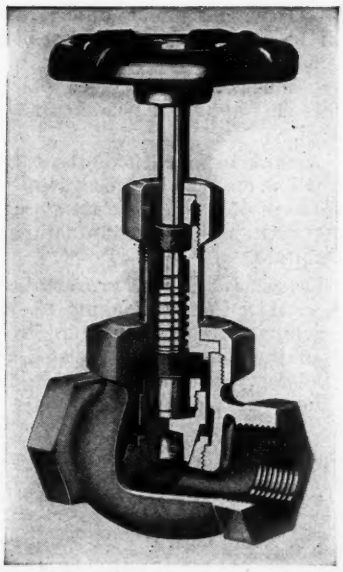
Pittsburgh, Pa., is particularly adapted as it insures a smooth continuous pipe line flow, sealing itself tight in the open and closed positions, a protection to the seat rings against wear.

The valve is designed to unseat axially each time before plug valve "A" is rotated to either open or closed position, and, it is possible from the outside, quickly and easily to adjust the valve for any clearance of 0.01 to 0.06 in. while rotating the plug valve "A", without friction or rubbing wear.

Two-way, three-way and four-way designs are available in bronze, iron, steel or other metals according to the service conditions and requirements and in screwed and flanged ends in ½ in. sizes and larger for all service pressures.

Plug Type Valve

DESIGNED FOR SERVICE where there is excessive wire drawing or destructive action on the valve seat or disc a new plug valve with long seating surface between the plug and the seat to insure added life is being offered by The Fairbanks Co., New York, N. Y. The seat ring is screwed into the diaphragm, pro-

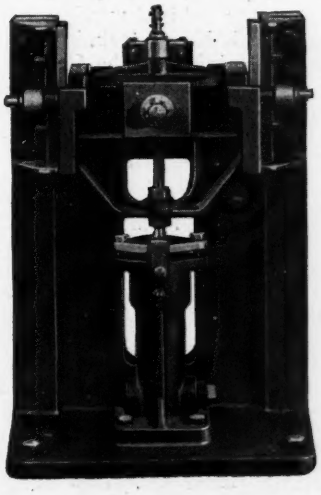


viding easy renewal. Both seat and disc are made of special nickel alloy of high Brinnel hardness and can be reground indefinitely without removing the valve from the line. A shoulder on the spindle affords a back seat which permits packing the stuffing box under pressure when the valve is wide open.

Chemical Pump

DEVELOPED ESPECIALLY for use in pumping exact quantities of water treating chemicals into water supplies at intervals, dependent upon the rate of water flow, a new chemical pump is announced by the Dearborn Chemical Co., 310 S. Michigan Ave., Chicago, Ill. The pump is adaptable to any type of liquid or semi-liquid chemicals and for close proportioning of coagulants.

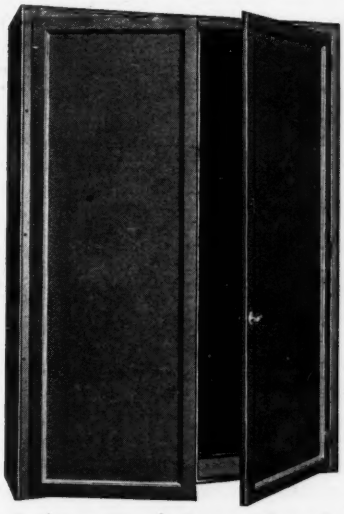
Stroke adjustment can be set



accurately from 0 to 3 in. with ordinary tools. Plungers are special alloy and all working parts are nickel semi-steel. The plungers and cylinders are interchangeable from ½ to 3 in. diam. The ½ in. cylinder operates safely up to 1800, the 1 in. to 1000 lb. pressure. Height overall is 23½ in., approximate weight, 125 lb.

Cabinet Meter Panel

EQUIPPED WITH DOORS to protect and conceal meter and control connections, a cabinet type steel meter panel is now being offered by Bailey Meter Co., Cleveland, O. The



paneled doors are provided with a 3 point locking mechanism and a substantial cylinder lock which may be used to prevent unauthorized persons from gaining access to electrical connections, control mechanisms and meter adjustments located within the cabinet. These panels are made of one piece sheet steel plate formed in proper sizes to give symmetrical and uniform appearance regardless of the quantity or type of meters and instruments to be installed on the board.

Hydraulic Refractory Concrete

QUALITIES and performance of hydraulic refractory concrete, developed by J. G. France Refractories Co., Snow Shoe, Pa., make it a valuable refractory for general use in plants where industrial and boiler furnaces are installed.

This monolithic hydraulic super-refractory called Hydrecon, as reported by the manufacturer, can be mixed with water without special precaution, can be poured into place without ramming, will set

uniformly throughout the mass to a very high cold strength, will maintain this strength to the highest temperature required, has a low shrinkage at high temperature and no shrinkage from time of pouring up to that temperature, has a high resistance to shock, abrasion and spalling, and can be heated and cooled repeatedly without rupture.

This combination is attained by passing suitable fire-clays through a chemical process, the reactions from which produce a bonding medium which sets by crystallization when water is added.

It is suitable for working temperatures up to 3200 deg. F. and sets to maximum strength in 48 hr. by crystallization, without heat.

Hydrecon has the following characteristics and ingredients, given in per cent: Set by crystallization, fusion point, 3290 deg. F., silica, 23.74; alumina, 69.00; iron-oxide, 2.00; lime, 2.00; magnesia, 0.06; titania, 2.00; alkalis, 1.00; loss on ignition, 0.20.

Great Lakes Show-Boat Power Exposition

NOVEL and distinctive in its manner of presentation, the Great Lakes Power Show and Mechanical Exposition, June 24-28, is to be installed on the four decks of the largest lake steamer, Seeandbee, and the entire show boat exposition moved on overnight hops between the three industrially important cities of Buffalo, Cleveland, and Detroit. At each port the ship will tie up for one full 14-hr. day, 10 a. m. to midnight. Thus a single exposition is enabled to reach in one period an industrial area encompassing over 20,000 major power-consuming industrial plants.

Over 200 booths of uniform size are being provided. Half of these will be located on the main exhibit floor of the first or entrance deck. The exhibit space available is equivalent to or in excess of that of the larger convention halls and hotel concourses in common use for power displays. The exposition will be complete in every detail and will include the most modern and up-to-date in power equipment and mechanical supplies.

The boat has been completely rebuilt to accommodate this newer type of service and each inch of available space has been utilized. Commodius stateroom, dining, and lounging facilities have, however, been preserved for a passenger list of 500 persons. The entire boat will be decorated on a show-boat theme. Those who feel that one day's inspection would be inadequate may apply for passage on the vessel.

Admission at each of the three visited ports will be free. Dealers will be invited to coöperate at each port with national manufacturing exhibitors.

Ernest H. Smith, president of the Hollow Center Packing Co. of Cleveland, is the managing director of the show and is assisted by an advisory board of nine leaders in the power field.

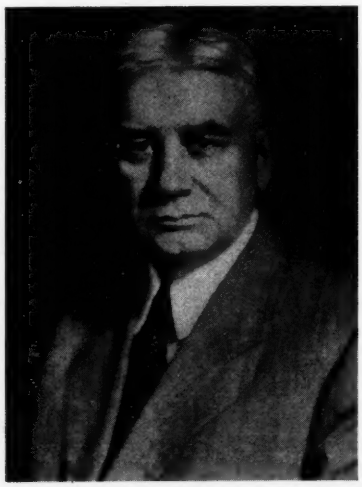
Dr. Pupin Dies

DR. MICHAEL I. PUPIN, professor emeritus of electro-mechanics at Columbia University and one of the outstanding figures in the field of electrical science twenty-five years ago, died at the age of 76 on March 12 at the Harkness pavilion of the Columbia Presbyterian Medical center where he had been ill for several weeks. Dr. Pupin who was born in Idvor, Banat, then in the province of Hungary but now in Jugoslavia, on Oct. 4, 1858, of peasant parents, was largely responsible for the development of the so-called "loaded" telephone line which made long distance telephony possible. The principle of "loading" involves the adding of lumped inductances in the telephone circuit at uniform intervals and in such manner that they counteract the natural capacity effect of the line. Pupin's mathematical analysis of the problem is now a classic and its practical application in the telephone communication revolutionized telephony. He also contributed to the field of wireless telegraphy and X-ray technique. He was the recipient of the John Fritz medal in 1932 and during his later years occupied posts of high honor in various scientific societies.

W. S. Elliott

LATE ON THE EVENING of February 21, W. S. Elliott, president and founder of Elliott Co., died suddenly from a heart attack at the age of 71. Mr. Elliott was born in Ohio, graduated from Cornell as a mechanical engineer in 1887, and at first embarked in the street railway business. Later he joined the Stirling Boiler Co. This brought to his attention the importance and the necessity of cleaning scale from the tubes of water tube boilers and he immediately interested himself in the problem with the final result that in 1901 he incorporated the Liberty Manufacturing Co. in Pittsburgh to manufacture boiler tube cleaners. He later transferred the charter of the Liberty Manufacturing Co. to a new company known as Elliott Co. and started to broaden his manufacturing interests with a line of power plant accessories.

In 1916 he took over The Lagonda Manufacturing Co. of Springfield, Ohio, as a subsidiary



company. In 1918 he started the manufacture of heat exchange equipment, including condensers and feed-water heaters. In 1923, through the purchase of the Kerr Turbine Company of Wellsville, New York, he entered the manufacture of steam turbines, and in 1926, he purchased the Ridgway Dynamo and Engine Company of Ridgway, Pa., with its line of engines, generators, motors, blowers, and electrical machinery. This plant has since been operated as the Ridgway Works, of Elliott Co., under the direction of his eldest son, G. F. Elliott.

Of the many definite contributions Mr. Elliott made to the art and development of power plant engineering, probably the outstanding example was his pioneering of the process of deaeration,—removing dissolved air and gases from water to prevent corrosion and for which, in 1924, the Franklin Institute awarded him The Edward Longstreth Medal.

News From the Field

INTERNATIONAL NICKEL Co. of Canada, Ltd., reports for 1934 net profit of $18,487,478.80, after all charges including depreciation. After payment of dividends on preferred stock, this leaves $1.13 per share of common stock as compared to 53 cents in 1933 and net loss of $135,344.65 in 1932.

SUPERHEATER Co. reports for the year 1934 earnings of $502,246.05, an increase of $186,291.03 over 1933, profit of $228,923.33 as against net loss for the two preceding years, taxes 25.5 per cent of the total net profit, dividends of 50 cents per share paid without disturbing surplus. The Superheater Co. now controls The Superheater Co., Ltd., of Canada, Combustion Engineering Co., Inc., The Air Preheater Corp., The Superheater Co., Ltd., of England and Compagnie des Surchauffeurs of France.

W. A. HAUCK has been appointed Assistant to the President of Lukens Steel Co., Coatesville, Pa. He is a graduate of Lafayette College with the degree of mining engineer and was formerly Assistant Comptroller of Bethlehem Steel Corp. Subsequently, he was connected with George W. Goethals, Inc., in company management and engineering work, and was also associated for several years with a New York stock exchange firm in underwriting and reorganization work. Prior to joining Lukens, he was with the American Iron and Steel Institute, engaged in work in connection with the Code of the Iron and Steel Industry.

APPOINTMENT of Atlas Supply Co., Inc., 35-39 Woodward Ave., Brooklyn, N. Y., as warehouse distributors of rust-resisting Toncan Iron sheets has been announced by N. J. Clarke, Vice President in Charge of Sales, Republic Steel Corp., Youngstown, Ohio.

W. A. NEILL has recently joined the Worthington Pump & Machinery Corp. organization as manager of its Mining and Construction Department which has recently been formed, with headquarters at Harrison, N. J., to simplify direction of its sales and service in the mining, quarrying and construction equipment fields.

IMPROVEMENTS to the municipal power plant at McPherson, Kans., are being carried out under the direction of Burns & McDonnell Engineering Co. of Kansas City, Mo. The present project includes a new 3000-kw. turbo-generator with condenser and auxiliaries, a new turbine room building, forced draft cooling tower and a new induced draft fan for the boiler room. Some of the equipment, including the Marley cooling tower, Elliott turbo-generator, Westinghouse condenser, Shaw-Box crane, DeLaval circulating pump, Elliott feedwater heaters and Griscom-Russell evaporator, have already been purchased. It is expected that the boiler feed pump, piping and electrical wiring contracts will be let soon.

DATE OF THE Midwest Engineering and Power Exposition to be held in Chicago has been set forward to Oct. 14 to 18. Floor plans and data are now available at No. 1 No. La Salle St., allotment of space to be made according to priority of receipt of request for information. The field covered will include all kinds of power plant and power utilization equipment, also regulating and control systems, building and operation materials and accessories.

J. LEE RODGERS, 57, Vice President and Treasurer of National Valve & Manufacturing Company, Pittsburgh, Pa. died suddenly on February 10. Mr. Rodgers was one of the original founders of the company 27 yr. ago, and was connected with it continuously up until the time of his death.

THE NATIONAL OIL and Gas Power Meeting will be held in Tulsa, Oklahoma, May 8-11, at the Hotel Mayo, it was announced by Ralph Miller, Chairman of the Oil and Gas Power Division of the American Society of Mechanical Engineers. The meeting will be held jointly with the Mid-Continent Section which will arrange one half of the program. This half will deal with Diesel problems of the oil fields. L. H. Morrison, of New York, will have charge of arranging the other half of the technical program which will cover developments of national interest in the Diesel field. The local arrangements Committee, of which J. F. Eaton is Chairman, is planning as part of the program several interesting inspection trips to Diesel plants in that area. This is the first time this national meeting has been held in the oil country and an excellent meeting is promised.

THE 1934 LAMME MEDAL of the American Institute of Electrical Engineers has been awarded to Henry E. Warren, President, Warren Telechron Company, Ashland, Mass., "for outstanding contributions to the development of electric clocks and means for controlling central station frequencies", and will be presented at the Summer Convention of the Institute, which is to be held at Cornell University, Ithaca, N. Y., June 24-28, 1935.

THE COLLEGE OF ENGINEERING of the University of Illinois, through its Department of Mining and Metallurgical Engineering and Department of Mechanical Engineering will offer another Short Course in Coal Utilization at Urbana on June 11, 12, and 13, 1935. The registration at last summer's Short Course was 146, and included men from states as far distant as Utah, Alabama, South Carolina, and Pennsylvania. There will be no charge for tuition or registration. The program is now being prepared and will probably be announced by April 1st.

ALLIS-CHALMERS MANUFACTURING Co., Milwaukee, Wis., announces the removal of its Pittsburgh district office to 2037 Koppers Building. Guy V. Woody is manager of the Pittsburgh district.

For the Engineer's Library

GENERAL ELECTRIC Co. has recently issued two new catalogs, one designated GEA 897E on Air Cooled Transformers for Lighting and Power Service and the other, GEA 1305C, covering Luminous Tube Transformers. The latter describes a new line of transformers for use with luminous tube signs. It presents considerable general information on the use of luminous tube signs and is well illustrated.

Bulletin GEA 1075A also issued by the same company describes New Temperature Indicating Equipment for A. C. Generators, Motors and Transformers.

SUPERSEDING AND AMPLIFYING the 1930 edition, the new "NEMA Motor and Generator Standards" has recently been issued by the National Electrical Manufacturers' Association. This new edition brings together much not published heretofore and constitutes a reference work of practical information concerning the manufacture, test and performance of A. C. and D. C. Motors, Generators and combinations of both.

"ANHYDREX RUBBER INSULATION," for wires and cables is the title of a 16-page booklet recently issued by the Simplex Wire and Cable Co., Cambridge, Mass. Anhydrex is the special rubber insulating compound used by this company on wires and cables that are subjected in service to partial or complete submersion in water.

THE GENERAL REFRACTORIES Co., 106 South 16th Street, Philadelphia, Pa., has just prepared for distribution an interesting series of 10 booklets on their Company, products and fields. One of these called "Refractory Products and Service" gives complete information on the Company and its 20 plants, sales offices, testing laboratory and miscellaneous refractory products. Four booklets deal with the products Fire Clay Brick, Plastic Fire Brick, Chrome Base High Temperature Cement, and Fire Clay and Cyanite Base High Temperature Cements. There are four on important fields and the uses of refractory products in these fields—namely, Boiler Plants, Metallurgical Processes (Ferrous and Non-Ferrous), Oil Refineries, and Rock Products Industries (Cement, Lime, Gypsum, etc.). A separate booklet deals with the Company's refractories produced in southern plants, called "High Grade Refractories from the South."

SINGLE-STAGE VOLUTE Type R centrifugal pumps, in sizes from 1½ to 2½ in., capacities from 30 to 45 g.p.m. and for heads of from 10 to 425 ft. are described in bulletin W-311-B1B by the Worthington Pump & Machinery Corp., Harrison, N. J.

STEEL MIXTURE Furnace Linings and Arches is the title of a new catalog, No. 235, issued by McLeod & Henry Co., Troy, N. Y. It describes the composition and shows forms and uses of blocks for door arches and jambs, side and front walls, bridge walls, combustion arches, air-cooled walls and Dutch-oven furnaces, with method of support for flat suspended arches. Use of Steel Mixture high-temperature refractory cements and shapes of fire brick for furnace construction are also given in this 30-p. bulletin.

DECATUR PUMP Co., Decatur, Ill., is sending out leaflets describing its Niagarette pumping units for small water systems and its Tornado condensate return units for heating systems.

GAS REGULATORS for natural and manufactured gas services are fully described in the 76 page 1935 catalog of the Chaplin-Fulton Mfg. Co., Pittsburgh, Pa.

FRICK REFRIGERATION AFLOAT is the title of bulletin No. 530-A of the Frick Co., Waynesboro, Pa. Many photographs of equipment and ships all over the world are shown and salient points of the equipment pointed out.

JOHNS-MANVILLE, New York City, has issued a bulletin illustrating and describing the Transit pressure pipe which is composed of a mixture of asbestos fiber and Portland cement and is made in five pressure classes for heads up to 500 ft. of water and is highly corrosion resistant, non-tuberculating and immune to electrolysis.

D. O. JAMES MFG. CO., Chicago, Ill., in its new 95 page catalog No. 137 describes and illustrates its line of gears and speed reducers. Included also are price lists and tables of useful data.

A NEW LINE of air circuit breakers known as type HD (Heavy Duty) developed recently by Roller-Smith Co. of New York are described in their new catalog No. 5. These breakers, rated at from 5 to 10,000 amp., 750 b., a.c., 600 v., d.c., are built either in the live front, dead front or steel enclosed types.

ROLLER-SMITH COMPANY, 233 Broadway, New York City, has just published new Switchgear Catalog No. 8. Switchgear is not a new development with the Roller-Smith Company but the fact that it manufactures a wide variety of switching equipment will be of interest. The line includes simple control panels, open and enclosed dead front equipment; cubicles; metal-clad gear; switch houses and special equipments of many kinds. The Roller-Smith Company makes most of the component items such as instruments, indicating and graphic; circuit breakers, air and oil; relays and instrument and control switches.

B. F. GOODRICH CO., Akron, O., has compiled a new book of engineering data, designed to simplify the selection of belting, hose, and other mechanical rubber goods for industrial service. Included in the section on transmission belting is a discussion of the relative merits of rubber and leather, a review of belting requisites for a wide variety of uses as well as helpful tips on installation procedure.

ROBINS CONVEYING BELT CO., 15 Park Row, New York City, has just issued bulletin No. 93 describing the Robins Vibrex Screens which is a new product of the company used for accurating sizing of fine materials. It has uniform motion, instant angle adjustment, self-absorbed vibration and a construction which permits mounting on horizontal or inclined supports or by cable suspension.

WATER TREATMENT for the prevention of scale and corrosion in internal combustion engines is discussed in bulletin No. W-90 issued by the Rathbun Co., Inc., El Paso, Texas.

BINKS MANUFACTURING CO., 3106 Carroll Ave., Chicago, Ill., is distributing an 8-page bulletin on indoor forced draft spray cooling towers presenting complete information about constructional features, picturing a number of installations, showing typical arrangements, and giving size and capacity data and specifications; also a similar 8-page bulletin devoted to atmospheric spray cooling towers for air conditioning and refrigeration, with complete engineering information and other helpful data.

FEED WATER REGULATORS, a 16-page bulletin designated as No. 83, is being distributed by Bailey Meter Co., Cleveland, O. This bulletin diagrammatically illustrates the principle of operation by the thermo-hydraulic generator, describes regulating valves of both tight seating and sleeve type construction and includes data on excess pressure valves also.

THE LUNKENHEIMER CO., Cincinnati, Ohio, has just issued a folder describing the company's new air nozzles with renewable non-metallic discs.

LEATHER PACKINGS is the title of a booklet recently issued by Alexander Bros., 406 N. Third St., Philadelphia, Pa., which describes the company's packings for hydraulic and pneumatic service on presses, elevators, hoists, pumps, brakes, jacks, compressors, pneumatic tools, valves, etc.

SUBSTANTIAL ECONOMIES effected in every branch of industry by the lubrication engineer are described in a monograph recently issued by Standard Oil Co. (Indiana) as an introduction to its new series of monographs completely covering all phases of industrial lubrication.

From the numerous citations in The Lubrication Engineer of authenticated examples of economies effected in many types of industries, the following random selections are typical: The cutting of one Illinois concern's total lubrication costs 53 per cent, the saving of $20,000 annually in lubrication costs of a mill, the solving of a shoe manufacturer's problem when he turned from sewing to glueing soles, and a lubrication recommendation in a metal working plant which both increased the life of drills used in reaming a tapered hole in treated alloy steel of unusual hardness and resulted in a smoother finish to the work.

Other monographs published in the new series during February were The Lubrication of Mine Locomotives, The Lubrication of Beaters and Jordans, The Lubrication of Diesel Air Compressors, and Diesel Engine Bearing Lubrication. Four or five additional monographs will appear each month of the entire year.

Prepared by Standard's engineering department and available upon request, they present in plain terms and by striking illustrations a detailed analysis of every specific lubrication problem in each industry, and give the solution conducive to maximum economy and efficiency.

ASSOCIATED BUSINESS PAPERS through a special committee has investigated the question of old age pensions, the findings being available in a report which can be had from its headquarters at 330 W. 42nd St., New York City, at a cost of 10 cents. Review is given of the various state laws, of proposed federal legislation and of experience with industrial pension plans and trade union pensions. Almshouses are found to be 3 to 5 times more expensive than outside cash assistance. Personal savings and insurance have not been widely effective and individual annuity purchase has been negligible, though group annuity projects have had some important recent development. Pension at age 65 seems most common, the range being from 50 yr. to 70 yr. Some 6,600,000 persons more than 65 yr. of age are now in the United States of whom 2,700,000 are entirely dependent. As a conclusion the committee recommends the contributory type of pension plan, generally used in other countries, as offering more protection than public funds alone and assisting in maintaining the self respect of those receiving pensions.

KRANE KAR and Krane Krawler, made by Silent Hoist Winch & Crane Co. of 762 Henry St., Brooklyn, N. Y., are described and illustrated in a 12-p. booklet, Bulletin No. 45 of that company. The outfits, gasoline engine driven swing boom crane mounted on a rubber tired car or a diesel-driven crane on a crawler tractor, are shown by dimensioned blueprints, as well as by photographs.

ELLIOTT CO., Pittsburgh, announces through its Heat Transfer Department at Jeannette, Pa., a new publication on steam jet ejectors. The bulletin illustrates and describes a wide range of ejectors from a small 1 in. priming ejector up to 30-in. booster ejectors. The bulletin just published goes into the theory and operating principle of steam jet ejectors, describes single and multistage ejectors, boosters, materials of construction, facts concerning operation, and the application of ejectors to numerous processes.

A NEW 52-page catalog outlining in detail the extensive services rendered by L. O. Koven & Bro., Inc., 154 Ogdin Ave., Jersey City, N. J., to the industrial field has recently been published. Illustrated with examples of the equipment designed by Koven engineers in coöperation with their clients, this catalog covers the entire range of plate and sheet metal construction in all commercial metals and methods of construction. Among the individual sections making up the catalog are: Tanks for Process & Storage. Equipment for the Chemical & Allied Industries. Mixers. Equipment for Food Industries. Equipment for Machinery, Metal Product Plants, Public Utilities, Railroads, etc. Containers. Sinks & Tables. Miscellaneous Plate and Sheet Metal Construction, including chutes, hoppers, piping, stacks. Marine Equipment. Built-up Welded Construction.

BROOKE ENGINEERING CO. of Philadelphia, in its bulletin No. 8, describes and illustrates with drawings and photographs its Fuel-Air-Ratio, combustion control system.

CARL SCHLEICHER & SCHULL CO., New York, has just issued the second and revised edition of its handbook for the chemist, entitled Filtrations in Chemical Laboratories. This booklet covers the range of filtrations in all industries from metallurgical plants to food products and tanneries. Copies may be had upon application to the above company.

DIESEL ENGINES ranging in sizes from 25 to 1000 hp., from 1 to 8 cylinders are covered in a 16 p. booklet, bulletin S-500-V6D of the Worthington Pump & Machinery Corp., Harrison, N. J.

BUREAU OF MINES Report of Investigation 3263 by H. F. Yancey and J. A. Taylor has just been published and discusses the froth flotation of coal, sulphur and ash reduction.

BUCKET ELEVATORS is the title of catalog No. 565 recently issued by The Jeffrey Mfg. Co., Columbus, Ohio. This catalog deals with standardized equipment for general service and gives a vast amount of informtaion helpful in the selection of conveying equipment.

CAUSUL METAL gate valves for corrosive service are described in a bulletin just issued by the Lunkenheimer Co., Cincinnati, Ohio. Causul metal is an austenitic ferrous alloy containing a high percentage of nickel, also some copper and chromium.

PLIBRICO JOINTLESS FIREBRICK CO., Chicago, Ill., has just issued an attractive bulletin entitled Beco-Turner Baffles which is a product recently taken over from the Boiler Engineering Co. The bulletin describes the various designs of Beco-Turner baffles which are built up with expansion joints giving blueprints and photographs of a number of installations.

THE MEDART CO., 3500 De Kalb St., St. Louis, Mo., has just issued its catalog No. 56-G containing standard listings, weights and dimensions of gears, sprockets and chains.

UNION IRON WORKS, Erie, Pa., is distributing a new bulletin on the Union Radiant Heat Boilers which not only describes the construction of the boiler but gives results secured in a number of installations.

EVERLASTING VALVE CO., 49 Fisk St., Jersey City, N. J., has recently issued its bulletin E467802 describing the features of principal interest in Everlasting valves, going into considerable detail with line drawings, photographs, dimensions and prices.

AIR FILTERS are described by the Coppus Engineering Corp. of Worcester, Massachusetts, in two new bulletins recently published. One bulletin, No. F-320-3, describes the Coppus unit type filter for motor and generator intakes, and general commercial and industrial ventilation. The other, No. F-310-2, contains complete data on filters for air compressors, internal combustion engines, etc. Sizes, shapes, and capacities of filters are given in tabular form in this bulletin.

UNDERWRITER APPROVED, single-stage, volute centrifugal fire pumps, Type LG, are described in bulletin W-320-B1 recently published by the Worthington Pump & Machinery Corp., Harrison, N. J.

THREE BULLETINS have recently been issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. These are Bulletin No. 269, Laboratory Tests of Three-span Reinforced Concrete Arch Ribs on Slender Piers; Bulletin 271, Determination of Mean Specific Heats at High Temperatures of some Commercial Glasses; Bulletin 272, The Creep and Fracture of Lead and Lead Alloys. A limited number are available for free distribution.

OIL PRESSURE SYSTEMS consisting of two motor driven pumps, an oil storage tank with the necessary piping and switch control for use with pressure regulators are described in a four page bulletin, No. 56, issued by the Ruggles-Klingemann Mfg. Co., Salem, Mass. This equipment is designed primarily for locations where an oil pressure system is applicable or where water pressure for the operation of regulators is not available.

WATER TUBE BOILERS of the all steel sectional type as built by the Springfield Boiler Co., Springfield, Ill., are described in a new 40-page catalog No. 35. In addition to the details of construction of the boiler, many typical installations are illustrated by photographs and drawings and the last page of the catalog is devoted to suggested rules for the care and operation of power boilers.

✓ MARKETING INDUSTRIAL EQUIPMENT. By Bernard Lester. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York City. Size 6 by 9 in., cloth bound, 296 pp. Price $3.50.

As the first comprehensive study of the problems involved in the distribution of durable or capital goods from the manufacturer to the ultimate consumer this book is an important step in bringing the distribution of machinery up to the high standards set by the engineering departments in its design and manufacture. It deals specifically with methods of market and product analysis, principles involved in the economic distribution, organization and operation of the sales department and sales outlets.

It is the outgrowth of a graduate course in marketing started by the author in September, 1931, at the University of Pittsburgh. As indicated in the title, the book covers in a careful way the analysis of product, market, competitors' distribution, the organization of the sales department, customer analysis and sales promotion from a practical point of view. Capital goods are generally not sold by high-pressure salesmanship and the book makes no effort to touch this particular art of selling. This difference or distinction between the usual salesmen of household appliances, for instance, and the group of salesmen selling heavy or capital goods equipment is well illustrated by the psychological studies of Johnson O'Connor in which the reaction of the latter group of salesmen is almost invariably of the engineering rather than the salesman group.

THE WATER JET PUMP. By James E. Gosline and Morrough P. O'Brien. Published by the University of California Press, Berkeley, Cal. Size 7 by 10 in., 190 pp. Paper covered. Price $0.35.

The water jet pump is in the same general class as injectors and steam-jet air pumps but possesses the decided advantage of not involving compressibility or heat transfer. The theory and operation of this type of pump, first used in 1852, is developed in this bulletin which is one part of a comprehensive study of the basic types of water pumps started several years ago in the hydraulic laboratory of the University of California. The most important result of this work is the verification of the theoretical equations and the statement of these equations in dimensionless terms. The agreement between theory and practice is good and operating characteristics can be predicted with a high degree of accuracy.

ELECTRICAL YEAR BOOK, 1935 edition. 312 pages, cloth, size 4 by 6¼, illustrated. Published by Emmott and Company, Ltd., Manchester, England. Price 1/6 net.

This is the 28th year that this little book has been published. It is an excellent little handbook and this year it includes a new section on the subject of rectifiers, which should be of value to everyone in need of a limited supply of direct current. The general information on electrical engineering which has made the book popular for years is of the same general nature as heretofore but has been extensively revised to bring it up to date.

✓ DIESEL HANDBOOK. By Julius Rosbloom. Published by Diesel Engineering Institute, Jersey City, N. J. Size 5½ by 5½ in., 528 pages, flexible fabricoid cover. Price $5.

This is the second edition of a practical book on all types of Diesel engines, a large part of it being in the Questions and Answers form, covering not only the construction of the engines but the general theory, operation and certain amount of mathematics. One of the sections deals primarily with regulations and rules of various insurance companies, etc., with marine license laws and regulations of the United States and Great Britain.

WATER SUPPLY IN BUILDINGS, by Alexander W. Moseley, paper bound, 92 pages, illustrated, copyright 1935. Mumm Print Shop, Evanston, Ill. Price $1.15.

Water Supply in Buildings is a compilation of engineering data put together in handbook style for engineers having to do with the design of water supply to buildings, operating engineers in charge of water supply systems, pipe fitters and contractors who are in charge of maintenance, alterations and extensions to piping systems. The book contains many tables of immediate use to men in charge of water systems and is written as far as possible without involved mathematics or theoretical discussion, in the language of the tradesman.

GAS, COKE, and Byproduct-Making Properties of American Coals and Their Determination is the title of Monograph 5 of the Bureau of Mines, written by A. C. Fieldner and J. D. Davis and printed by the American Gas Association, 420 Lexington Ave., New York. The paper presents results of work done under a cooperative agreement between the Bureau of Mines and American Gas Association and discusses in detail the examination and test of some 30 coals tested at various carbonizing temperatures ranging from 500 to 1100 deg. C.

MECHANICAL WORLD YEAR BOOK, published by Emmott & Co., Ltd., 31 King St. West, Manchester, England. The 48th Edition of this popular publication has been enlarged to include two of the outstanding trends in modern industry. One section on compressors presents the subject matter in a way to facilitate general application and the one on pumps deals particularly with the selection of pumps to meet specific conditions. Another new feature of the Year Book is the arrangement of certain sections in alternate editions. In this way any two consecutive issues cover a wider field than is possible with one alone. The tabular matter, in many cases condensed data from other sections are included in each edition.

TWO PAPE-SWIFT REFERENCE BOOKS have recently been published by the John S. Swift Co., Inc., 105 South 9th St., St. Louis, Mo. Both books sell for a dollar a copy plus ten cents postage. The first, with 439 pp., is a boiler reference book containing complete information on boiler heating surface, boiler numbers, grate area, manufacturers ratings, etc., on heating boilers of various manufacturers. This book does not repeat or duplicate the information in the 1934 book. It is a complement of the 1933 edition and both books are necessary for a complete file. The second book, of 311 pp., contains the specifications and ratings on modern, obsolete and concealed types of radiators built by various American manufacturers.

AIR CONDITIONING. By James A. Moyer and Raymond U. Fittz. Published by McGraw-Hill Book Co., size 6 by 9 in., cloth bound, 373 pp. Price $4.

Air conditioning in theory and practice is covered by this book which is intended as a general and comprehensive treatment of air conditioning for all purposes. The book starts with the general theory, covers the various cooling and humidifying methods, types of equipment and then goes into the application of these to specific requirements, such as office buildings, theaters, restaurants, food factories, textile mills, service institutions, etc.

Power Plant Construction News

Ark., Blytheville—Blytheville Canning Co., plans installation of steam power equipment in connection with expansions and improvements at food products canning plant. Cost about $25,000. George Greb is president.

Calif., El Segundo—Northrop Corporation, El Segundo, near Los Angeles, manufacturer of airplanes and parts, plans installation of electric power equipment in new one-story addition, 60x140 ft. Entire project will cost about $45,000.

Calif., Marysville—National Ice Co., Ninth and A Streets, plans rebuilding of portion of local ice-manufacturing plant, recently destroyed by fire, with loss estimated at $40,000, including equipment. Reconstruction will cost approximately a like sum.

Calif., Randsburg—Anglo-American Mining Corporation, Ltd., Mills Building, San Francisco, Calif., plans installation of electric power equipment in proposed new cyanide mill at gold-mining properties, known as Yellow Aster Mine, near Randsburg. Plant will have capacity for handling about 200 tons of crude ore per day. Cost approximately $100,000. Hamilton, Beauchamp & Woodworth, Inc., 564 Market Street, San Francisco, is engineer.

D. C., Washington—Board of District Commissioners, District Building, will receive bids until April 9 for new sewage pumping station at Blue Plains, to be used in connection with new sewage disposal works, as per plans and specifications on file. Cost reported over $150,000.

Fla., St. Petersburg—Sunshine Lumber & Supply Co., plans installation of power equipment and mechanical-handling facilities in connection with proposed rebuilding of portion of mill, recently destroyed by fire. Loss close to $75,000, including equipment. Henry T. Isbell is president.

Ill., Chicago—Olson Rug Co., 2800 North Crawford Avenue, plans installation of power equipment in new six-story factory addition. A new power house will also be built. Cost over $100,000. Weiss & Niestadt, 343 South Dearborn Street, are consulting engineers.

Iowa, Boone—City Council is having plans completed for a new municipal electric light and power plant, for which it is proposed to call for bids at early date. Special election has been arranged to vote bonds for $850,000 for project. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ky., Louisville—Louisville Gas & Electric Co., 311 West Chestnut Street, is arranging fund of about $507,000 for expansion and improvements in power plants and system during 1935, including transmission and distributing lines, power substations and other facilities. A present 66,000-volt transmission line will be rebuilt. Company engineering department is in charge.

Mass., Lowell—City Council is considering construction of new municipal electric light and power plant. Estimates of cost will soon be made. James J. Bruin, mayor, is active in project.

Minn., Albert Lea—Wilson & Co., manufacturer of commercial fertilizers, plan installation of electric power equipment in new one, two and three-story plant addition. Cost over $85,000. Company proposes further plant expansion in near future to cost in excess of $250,000.

Miss., Hattiesburg—Domestic Silks, Inc., 463 Seventh Avenue, New York, N. Y., plans installation of electric power equipment in new one-story silk mill at Hattiesburg, 135x270 ft., where site has been acquired. Entire project will cost over $85,000. E. C. Hearon & Sons, Hattiesburg, are architects.

Mo., Kansas City—S. E. Massengill Co., 208 West Nineteenth Street, plans installation of electric power equipment in new one-story addition to chemical and pharmaceutical plant. Entire project will cost about $40,000. Keene & Simpson, Land Bank Building, are architects.

Mo., St. Louis—Monsanto Chemical Co., 1700 South Second Street, plans installation of electric power equipment at different plants in various parts of country, in connection with an expansion and improvement program in 1935, estimated to cost over $4,000,000. New buildings will be erected and betterments made in existing structures.

Neb., Bayard—Chimney Rock Power District, R. O. Chambers, Minatare, Neb., president, is planning construction of rural electric distribution system in parts of Morrill and Scottsbluff Counties, including power substations, switching stations and service facilities. Cost about $600,000. Financing will be arranged through Federal aid. H. C. James and H. H. Henningson, Union State Bank Building, Omaha, Neb., are consulting engineers in charge.

Neb., Beatrice—Southeast Nebraska Public Power District, Beatrice, is considering a rural electrification program covering construction of transmission and distribution lines, power substations and service facilities in neighboring rural areas. Cost about $500,000. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

N. Y., Buffalo—Niagara, Lockport & Ontario Power Co., Electric Building, is considering rural electrification program in a number of counties, including Orleans, Monroe, Niagara, Livingston and other counties, including new electrical distribution lines, power substations and service facilities. Extensions will be made in transmission lines to new territory. Cost reported over $400,000. Company engineering department is in charge.

N. Y., New York—Department of Docks, Pier A, North River, has been authorized by Board of Estimate, Municipal Building, to expend fund of $628,000 for mechanical equipment for new Pier 88, North River, foot of Forty-eighth Street, including conveying, elevating and other mechanical-handling equipment, power apparatus, etc.

N. Y., New York—Department of Water Supply, Gas and Electricity, Municipal Building, has preliminary plans under way for new steam-operated electric power plant at Bronx Terminal Market, to serve a group of municipal buildings in that district. Proposed to use Diesel engine-generator units. Cost over $700,000. Financing will be arranged through Federal aid.

Ohio, Cincinnati—Carthage Distilling Corporation, 7818 Anthony Wayne Avenue, plans installation of power equipment, conveying and other mechanical-handling equipment in new plant units, comprising three and five-story rectifying plant and seven-story storage and distributing unit, respectively. Cost over $350,000. Company engineering department is in charge.

Ohio, Niles—City Council has engaged Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer, to prepare plans for new municipal electric power plant. Cost about $500,000. Financing will be arranged through Federal aid. R. D. McLean is city engineer.

Ohio, St. Mary's—Auglaize Box Board Co., manufacturer of paperboard products, is considering extensions and improvements in steam power house at mill, including installation of new boiler and auxiliary equipment.

Ohio, Wellsville—Sterling China Co., plans installation of electric power equipment in connection with expansion and improvement program at pottery for increased capacity. Cost close to 155,000, including machinery.

Okla., Oklahoma City—Oklahoma Gas & Electric Co., has authorized fund of about $755,000 for expansion and betterments in electrical and gas properties during 1935, including transmission and distributing electrical lines, power substations, service facilities, etc. Company engineering department is in charge.

Ore., Portland—Safeway Stores, Inc., Fourth and Jackson Streets, Oakland, Calif., plan installation of steam equipment, conveyors and other mechanical-handling equipment in new branch baking and distributing plant at Third Avenue near Pine Street, Portland. Cost about $400,000. F. Marion Stokes, Terminal Sales Building, Portland, is architect.

S. C., Rock Hill—Rock Hill Bleachery & Dye Co., has approved plans for new one-story boiler plant at local textile mill, and proposes to begin work at early date. Cost about $25,000, with equipment. Robert & Co., Bona Allen Building, Atlanta, Ga., are engineers.

Texas, San Angelo—Texas Woolen Corporation, M. C. Cotton, 614 Winston Street, Dallas, Texas, president, recently organized, plans installation of electric power equipment in proposed new multi-unit mill at San Angelo, where large tract of land has been acquired. A power house will be built for mill service. Entire project will cost close to $400,000.

Va., Charlottesville—Frank Ix & Sons, Inc., plans installation of electric power equipment in new addition to silk mill, designed to increase output more than one-half. Cost reported close to $50,000, with machinery. Elmer E. Burruss, Charlottesville, is architect.

Wash., Everett—Weyerhaeuser Timber Co., Tacoma Building, Tacoma, Wash., plans extensions and improvements in steam-electric power plant at mills at Everett, in connection with proposed new pulp mill. Entire project will cost approximately $100,000. F. R. Titcomb is general manager.